Quality of the Environment

The quality of life mirrors the quality of the environment. As a technology and knowledge-based society, we are more capable and vigilant than ever about managing and monitoring pollutants released into the air, water, and soil. Nevada state agencies are responsible for the implementation of many laws intended to lessen impacts of activities that diminish environmental quality and impair the health and well being of people and other life forms. Agency programs deal with discharges of pollutants from large and small sources into the air, water, and soil; the prudent allocation and conservative use of limited water supplies; and, the safe use, transportation, and storage of solid and hazardous waste and toxic substances. Some programs are mandatory and prescribe protective standards and practices. Many others are voluntary, and require individual, industry, and community involvement to be successful. State agencies most extensively involved are the Divisions of Environmental Protection (NDEP) and Water Resources (NDWR), and the Department of Agriculture.

The information presented in Part 2 provides an overview of Nevada's environmental quality status and some of the programs implemented to sustain favorable air, water, and soil conditions. Information from state and local agencies indicates environmental values are being maintained in many areas of the state. However, deteriorated environmental quality is evident where land and water resources are intensively developed for urban, agricultural, mining, and military land uses. In the past couple of decades, regulations have resulted in improved pollution controls at large, easily identified pollution sources. Today, major threats to environmental quality come from numerous, dispersed, and smaller scale activities in both urban and rural areas. The expanding population and economy combined with the consumption habits of individuals, industries, and institutions make achievement of environmental standards dependent upon changes in the daily behaviors and choices of everyone. Education is an important strategy for gaining the broad support needed to make environmental progress. Resource agencies can contribute to public education by sharing the results of environmental monitoring data and assessments of program effectiveness. Ultimately, high environmental quality depends upon each citizen, industry, and community learning how to modify our lifestyles, work practices, and recreational activities that negatively impact the air, water, and soil resources.

Air Quality

The quality of air throughout almost all of Nevada is better than government standards set to protect the health and welfare of humans and the environment. The clearest air in the nation is found in rural eastern Nevada, based on monitoring of airborne particulates at Great Basin National Park. However, most of the state's population resides in two urbanized areas that are designated as having moderate to serious air quality impairment, relative to air quality standards. Air quality is determined by measuring concentrations of common pollutants near ground level, where people live and work. If concentrations for a pollutant rise above air quality standards for a specified period of time and number of days, then the airshed can be classified as "nonattainment." In nonattainment areas, State Implementation Plans (SIP) must be prepared by the air quality management agency. The SIPs demonstrate how proposed strategies, technologies, practices, and regulations will reduce pollution, improve air quality sufficiently to achieve standards, and maintain improved conditions.

The State of Nevada has set air quality standards for criteria pollutants that are generally based on the federal standards for air quality. Air quality standards specify the maximum pollutant concentrations over specific averaging periods. The six criteria pollutants for which standards have been set are sulfur dioxide, carbon monoxide, nitrogen dioxide, ozone, particulate matter, and lead. These pollutants are relatively common and capable of causing mild discomfort or seriously affecting the health of people when elevated concentrations persist. Perhaps the greatest success of the Clean Air Act was the nationwide reduction in the level of atmospheric lead brought about by mandatory removal of lead from gasoline. The Nevada State Environmental Commission also has established an air quality standard for hydrogen sulfide (H_2S), a toxic gas with a disagreeable odor.

Management of air quality in Nevada is handled by both state and county agencies. The Bureaus of Air Quality Planning (BAQP) and Air Pollution Control, within the NDEP, implement air quality programs for the state, with the exception of Clark and Washoe counties. The Washoe County District Health Department and the Clark County Department of Air Quality Management are responsible for the air pollution control programs and air quality monitoring in those jurisdictions.

Air Quality Status

Throughout the 1990s, the BAQ periodically monitored air quality in Carson City, Minden, Gardnerville, Stateline, Zephyr Cove, Fernley, Fallon, Lovelock, Battle Mountain, Elko and McGill. Results indicate that generally good air quality occurs throughout Nevada. The BAQ reports that monitoring data show no deterioration in the air quality of these areas between 1989 and 1999 (Bureau of Air Quality, 2000).

Table 2-1. Annual Number of Days that Air Quality Standards Were Exceeded In Non-Attainment Areas

Year	Carbon Monoxide		Particulate Matter		Ozone	
	Truckee Meadows	Las Vegas Valley	Truckee Meadows	Las Vegas Valley	Truckee Meadows	Las Vegas Valley
1990	6	13	6	3	4	1
1991	3	6	0	1	0	0
1992	0	2	0	0	0	0
1993	0	3	1	0	0	0
1994	0	4	0	0	0	0
1995	0	1	0	16	0	0
1996	0	3	0	17	0	0
1997	0	1	0	13	0	0
1998	0	2	0	6	0	0
1999	0	0	1	6	0	0

Sources: Clark County Department of Air Quality Management, personal communication. State of Nevada, Bureau of Air Quality 1989 – 1999 Trend Report.

Air quality standards have been exceeded in the two most populated air basins – the Truckee Meadows and Las Vegas Valley (Table 2-1). Within the Truckee Meadows non-attainment area are the cities of Reno, Sparks, and the Nevada side of the Lake Tahoe Basin. The Las Vegas Valley nonattainment area includes the cities of Las Vegas, North Las Vegas, Henderson, and Boulder City. Overall, the annual number of days when air quality standards were exceeded declined during the 1990's.

Las Vegas Valley is designated a serious nonattainment area for carbon monoxide and particulate matter. The Truckee Meadows basin is designated as a moderate nonattainment area for carbon monoxide and a serious nonattainment area for particulate matter. Both areas experience elevated ozone concentrations during the summer months. Anticipated standard changes may result in the classification of both areas as nonattainment for ozone. Because Nevada is a highly urbanized state, about 80 percent of the state's population lives within the particulate matter and carbon monoxide nonattainment areas.

Primary human-derived sources of particulate pollution include windblown dust from construction sites, unpaved roads and trails, sand and gravel operations, and off-road recreational vehicles. Secondary sources include motor vehicle emissions, residential wood burning stoves and fireplaces, wildfire and brush/waste burning, tilled and fallowed agricultural fields, toxic chemicals, and industrial sources. Particulate matter also can form when gases emitted from motor vehicles and industry undergoes chemical reactions in the atmosphere.

Carbon monoxide typically is higher during calm periods. A large amount of carbon monoxide comes from motor vehicles and wood burning for home heating. Other sources include lawn mowers, off-road vehicles and construction equipment. Federal rules have required placement of pollution controls on automobiles, thereby lowering emission rates from a portion of the vehicle mix. However, onboard emission controls have not been required on trucks and buses yet.

Air quality improvements from lower auto emissions may not be maintained due to demographic trends. Between 1991 and 1999, the amount of vehicle miles traveled (VMT) in Nevada increased 6.8 billion miles to 17.4 billion miles, a 65 percent increase (Nevada Department of Transportation, 2001). Population increased about 30 percent during the same period. A portion of the increased VMT may be attributable to tourism and suburban sprawl. More residential developments built distant from core urban areas translate into more workers and shoppers driving longer distances. Sprawl works against the local economy of scale to fund mass transit services, a pollution reduction strategy used in other metropolitan areas. An inspection and maintenance program for vehicles in the Reno and Las Vegas area helps to reduce vehicle tailpipe emissions. The use of oxygenated fuels, cleaner alternative fueled vehicles, vapor recovery at gas service stations, and improved on-board emission controls also lower pollutant emissions.

Air Quality Management

State and county air quality management agencies administer permitting programs to control and track emissions of the six criteria pollutants from a wide variety of sources. Emissions of volatile organic compounds (VOCs) are also regulated and tracked because this group of chemicals (e.g., petroleum based solvents) contributes to formation of ozone and some pose serious human and environmental health threats. Major stationary sources and hazardous pollutant emission sources are subject to stringent permits that specify the amount of emissions allowed, minimum pollution control measures, and monitoring and reporting requirements. Source emissions data is collected or estimated periodically and analyzed to check on permit compliance.

The state's BAPC issues permits for Nevada electric generating stations that burn fossil fuels. Although coal remains the primary fuel for electricity generation in Nevada (56 percent), natural gas fueled generation has increased to 20% over the past decade. More geothermal power plants have also been added to the state's generation mix, helping hold down pollutant emission increases. From 1988 to 1998, power plants in Nevada produced fewer tons of sulfur dioxide, declining from 61,000 to 54,000 tons (Table 2-2). However, nitrogen dioxide emissions rose from 69,000 to 76,000 tons. Carbon dioxide, a greenhouse gas associated with accelerated climate change and global warming concerns, also increased modestly.

Table 2-2. Electric Power Industry Emissions Estimates from 1988, 1993, and 1998

Emission Type	1988	1993	1998	Annual Growth Rate 1988-1998 (Percent)
	(Thousand Short Tons)			
Sulfur Dioxide	61	53	54	-1.2
Nitrogen Oxides	69	65	76	1.0
Carbon Dioxide	21,125	20,074	24,167	1.4

Source: U. S. Energy Information Administration. Website: http://www.eia.doe.gov/cneaf/electricity/st_profiles/nevada/nv.html

Air toxics, or hazardous air pollutants (HAPs) are compounds known or suspected to cause serious health effects or environmental effects. Common HAP's include benzene and toluene from gasoline, perchloroethylene from dry cleaning facilities, and methylene chloride from paint stripping compounds. Others are dioxin, asbestos, and metallic compounds (e.g., those with cadmium, mercury, chromium, and lead). HAP's that are persistent, such as mercury, may accumulate in the food chain, reaching higher levels than in the surrounding environment. Most HAP's originate from mobile sources. Forest fires may release large quantities. Stationary sources of air toxics are divided into major and area source categories. Few major sources, which include chemical plants, steel mills, oil refineries, hazardous waste incinerators, and power plants, are located in Nevada. Area sources, such as dry cleaners and gas stations, release smaller amounts, which though small, can be of concern where concentrated. The 1996 National Toxics Inventory data from the EPA show that mobile sources contribute 50 percent of our country's HAP's emissions, major stationary sources 26 percent, and area and other sources 24 percent.

Greenhouse Gases and Climate Change

The atmosphere contains gases that trap re-radiated energy from the sun, warming the earth, similar to a greenhouse trapping heat. "Greenhouse gases" – primarily carbon dioxide, methane, and nitrous oxide –

make up a fraction of one percent of all atmospheric gases. Without them, the earth's surface would be 34° F cooler. Because a small amount of gases exerts such a strong global effect, the continuing rise in greenhouse gas concentrations during the past century has generated intense scientific interest.

Measurements taken directly from the atmosphere since the 1930's confirm that carbon dioxide (CO2), the most plentiful greenhouse gas, has been increasing. Carbon dioxide levels for earlier times are inferred from measurements of CO2 trapped in air bubbles in glacial or polar ice. Concentrations have varied naturally throughout Earth's history, however, the 30% increase observed since pre-industrial times cannot be explained by natural causes. Carbon dioxide concentrations are higher now than in the past 450,000 years (U.S. Environmental Protection Agency, 2002). Table 2-3 shows calculated changes in greenhouse gas emissions in Nevada from 1990 to 1995. Total emissions increased 16.5 percent, corresponding with population and economic growth (Nevada Energy Office, 1998).

Table 2-3. Human Caused Greenhouse Gas Emission Estimates for Nevada, 1990 and 1995

Source	Gas	Carbon Dioxide Equivalent Emissions (tons)		Percent Change 1990 – 1995
		1990	1995	
Fossil Fuel Combustion Coal Petroleum Natural Gas	CO_2 CO_2 CO_2 CO_2	33,340,968 16,854,070 12,613,710 3,873,187	38,239,348 16,570,144 14,971,430 6,697,775	14.7 -1.7 18.7 72.9
Biomass Fuel Combustion	CO_2	167	206	23.2
Production Processes	All CO_2 N_2O	1,203,830 1,203,830	2,055,220 1,865,531 189,689	70.7 55.0
Natural Gas and Oil Systems	CH_4	144,976	245,563	69.4
Landfills	CH_4	561,351	684,285	21.9
Domesticated Animals	CH_4	819,204	757,460	-7.5
Manure Management	CH_4	82,635	86,940	5.2
Fertilizer Use	N_2O	20,460	38,750	89.4
Forest Management and Land Use Change	CO_2	-183,797	-183,758	0.0
Agricultural Burning	All CH_4 N_2O	326 202 124	269 176 93	-17.3 -12.5 -25.2
Wastewater Treatment	CH_4	20,727	26,166	26.2
Total (less Biomass) Carbon Dioxide Methane Nitrous Oxide	All CO_2 CH_4 N_2O	**36.010,680** 34,361,001 1,629,095 20,584	**41,950243** 39,921,121 1,800,590 228,532	**16.5** 16.2 10.5 1,010.2

Source: Greenhouse Gas Emission Inventory for Nevada, Nevada Energy Office and Desert Research Institute, 1998.
Notes: Carbon Dioxide Equivalent relates the warming potential of a molecule of carbon dioxide to a molecule of another greenhouse gas. For CH_4 the multiplier is 21, and for N_2O it is 310.

Climate scientists predict that average temperatures for the U.S. will warm 7°F by 2090. This change appears small compared to short-term weather. For global climate, such a warming would be larger and faster than any changes in the past 10,000 years. The global average temperature this past century has warmed 1° F. Computer climate models that evaluate the potential effect of expected warming on western water resources give insight into potential effects in the Sierra Nevada and Great Basin ranges. Possible impacts include: less snowfall and more rain; a shorter snowfall season; and accelerated snow pack runoff. Flashier, earlier, and greater spring runoff would lower supply availability during the growing season. Higher evaporation would reduce water storage in reservoirs, aquifer recharge, and soil moisture. Longer dry seasons would present new challenges to managers of Nevada's water supplies and aquatic ecosystems (Frederick and Gleick, 1999).

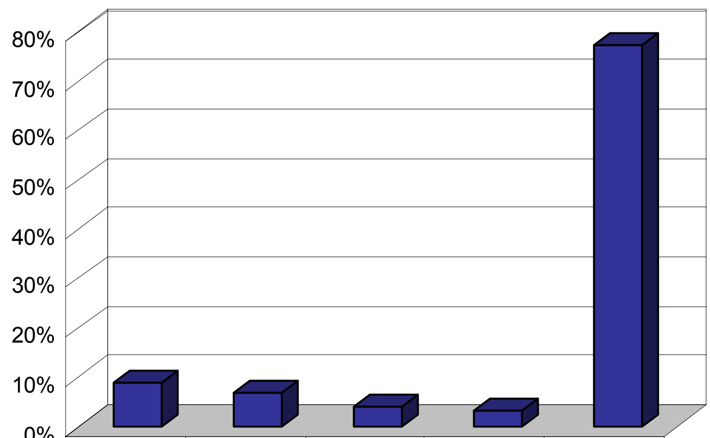
Water Resources and Supply

Water is Nevada's most precious resource and more than any other will determine Nevada's future. Wise management of water resources and protection of water quality is vital to the state's economic future and quality of life. Finding ways to stretch water supplies for new beneficial uses while maintaining existing beneficial uses is perhaps the biggest challenge confronting Nevada. The Nevada State Engineer, in the

Nevada Division of Water Resources (NDWR), administers state water law. The mission of NDWR is to conserve, protect, manage, and enhance Nevada's water resources through the appropriation and reallocation of the public waters. All surface and underground waters within the state belong to the public (Nevada Revised Statute 533.025).

Surface waters are limited and essentially fully committed. Ground water resources are approaching full commitment in the state's southern and western regions. In the fast growing counties, obtaining water to meet additional municipal or industrial uses requires the developer to purchase and obtain a permit to transfer water rights from agricultural uses. About three-fourths of the water withdrawn from surface and groundwater is used for agriculture (Figure 2-1). Negative consequences may result from agricultural water rights transfers. For example, browning of fallowed farmland and irrigated greenbelt areas (e.g., pasture, artificial meadows and riparian zones) can lead to nuisance weed cover, erosion of barren soil, and lost wildlife habitat.

Figure 2-1. Total State Water Withdrawals by Type of Use



	Domestic	Mining	Commercial	Other	Irrigation & Livestock
Use	8.9%	6.8%	3.8%	3.3%	77.2%

Source: Nevada State Water Plan, 1999.

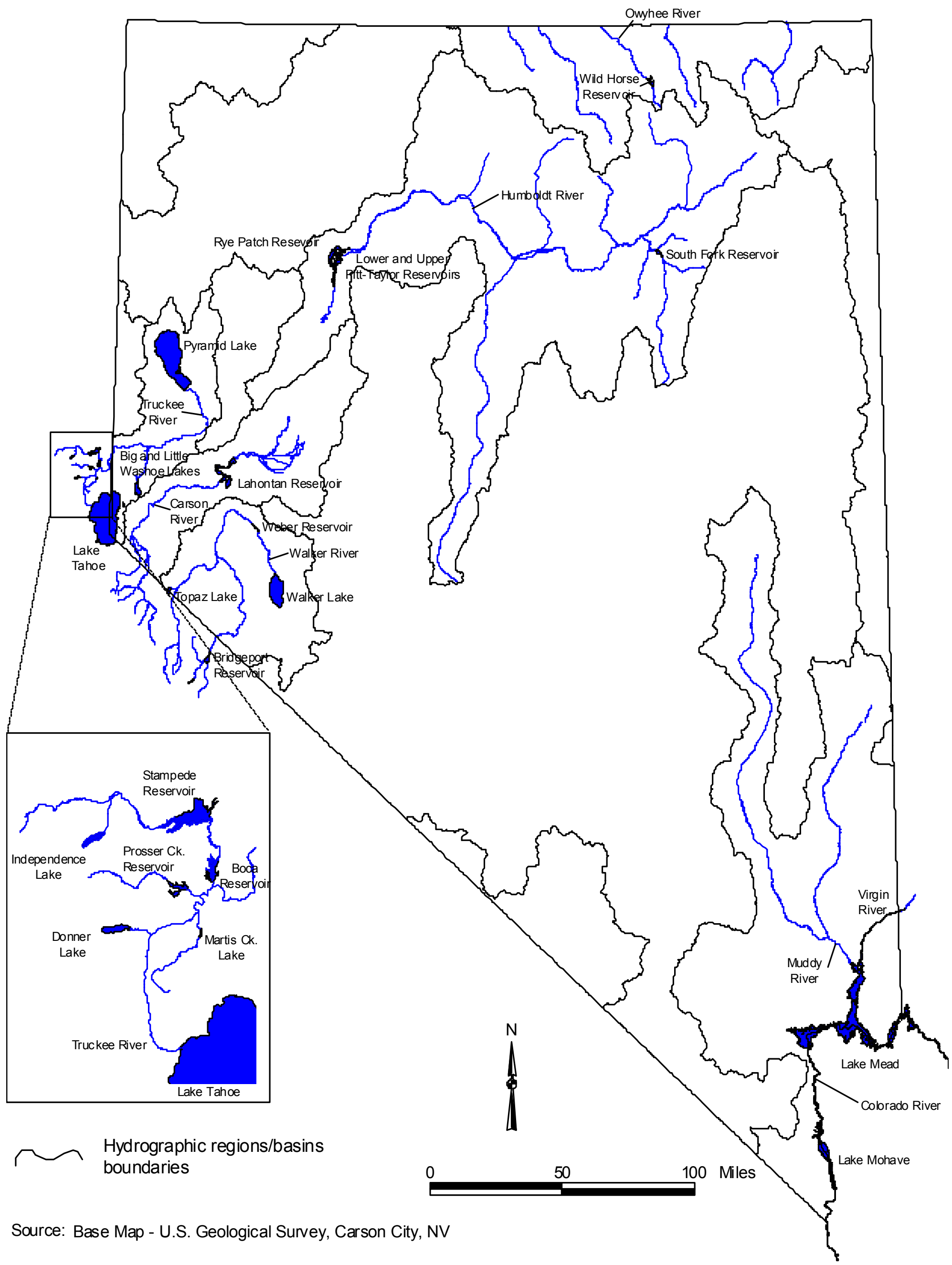
Awareness is growing that active management of water resources can improve supplies and quality, as indicated by an apparent increase in the number of stream channel, wetland, watershed, and groundwater recharge projects. Conservation also can extend limited water supplies, although a comprehensive state strategy has not been developed. However, municipal and industrial suppliers in Las Vegas Valley and Truckee Meadows are making progress, as are the Truckee-Carson and Pershing County irrigation districts. Only municipal suppliers are required to adopt a conservation plan. However, without periodic reporting, the status of conservation plans and achievements cannot be estimated.

Surface Water

Nevada's major rivers are shown in Figure 2-2. Surface water is the source of 60 percent of the total water supply used, and 72 percent of the residential, commercial, industrial and public use. The Truckee River and Colorado River provide drinking water for approximately 85 percent of all Nevada residents (i.e., Washoe and Clark county urban areas). Streamflow primarily comes from annual snowfall and melt, though groundwater flow may also augment flow in rivers and creeks where underground water bodies (aquifers) are connected to channels.

Annual and seasonal variation in surface water flow can be large. Maximum stream flow often occurs in May or June (peak snowmelt). With one exception, most of the flow in Nevada's major rivers originates in other states. Headwaters of the Carson, Truckee, and Walker rivers lie in California, and the Colorado River carries water from several Rocky Mountain States. The exception is the Humboldt River, which begins and ends in Nevada. Flow in the major rivers and streams follow a typical pattern. River channels gain most of the flow in the mountains, and then lose it as the channel traverses drier valleys. Stream flow losses come by evaporation, vegetative transpiration, percolation, and diversions for beneficial uses.

Figure 2-2. Major Streams in Nevada



Source: Base Map - U.S. Geological Survey, Carson City, NV

Water diverted for off-stream uses and not consumed by crops, people, or industry, and subsequently delivered back to the stream of origin is called return flow. Return flow is a vital component in the water use cycle, because the practice provides some assurance that water will be available for use in lower reaches.

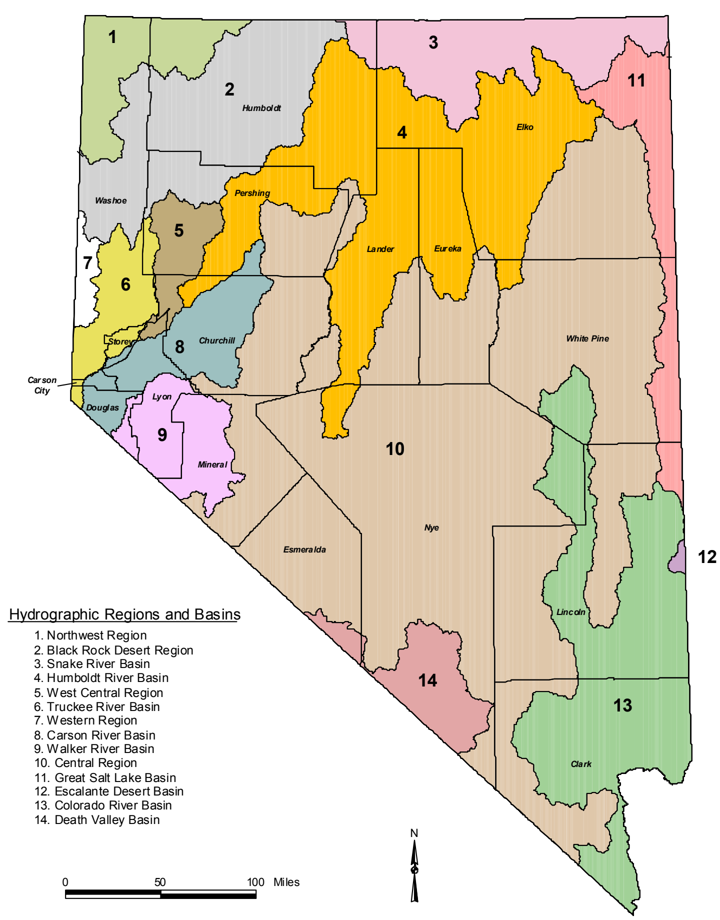
The estimated average annual yield from rivers and streams in Nevada is approximately 3.2 million acre-feet per year. For 1995, the estimated surface water withdrawals totaled 2.4 million acre-feet (Nevada Division of Water Planning, 1999a). About 1.9 million acre-feet originate in Nevada watersheds, and about 1.3 million acre-feet flows in from and 0.7 million acre-feet flows out to adjoining states. Surface waters have been fully appropriated for many years, though in wet years surplus water may be available. Streamflow reaching terminal basins can replenish lakes and wetlands that support a variety of habitat types, fishes, and wildlife; recharge groundwater; improve water quality; and provide outdoor recreation opportunities. Most priority rights for surface water in Nevada were established in the 1800's. Rights to use water for irrigation date back to the 1850's in streams draining the Sierra Nevada Range and to the 1870's and 1880's in the Humboldt River Basin. Additional dams and reservoirs would be needed to impound the water to detain surplus flows for later use.

Major Rivers, Lakes, and Reservoirs

Nevada contains 14 river basins and hydrographic regions (Figure 2-3). Five contain major rivers. Except for the Colorado River, Nevada's perennial rivers are comparatively small. Only the streams in the Snake River Basin (e.g., Owyhee, Bruneau, Goose, and Jarbidge) and Colorado River Basin flow to the ocean. All other streams discharge into alluvial fans along the mountains or into terminal sinks, which may contain lakes, playas, or wetlands. The major river systems in Nevada are the Colorado, Walker, Carson, Truckee, and Humboldt. Major lakes and reservoirs are listed in Table 2-4.

The **Carson River** flows in two main forks from the eastern slopes of the Sierra Nevada Range in California, into Carson Valley where the forks join. The main stem flows through other populated valleys – Eagle (Carson City), Dayton, and

Figure 2-3. River Basins and Hydrographic Regions in Nevada



Lahontan before the 184-mile long river empties into the Carson Sink (California Department of Water Resources, 1991a). Several small, regulated lakes and storage reservoirs located high in the basin help prolong the irrigation season. Waters of the Carson River are used primarily for agriculture. Important fisheries, wildlife, and water based recreation uses occur also, most prominently in the upper river reaches. Municipal and industrial users are supplied by groundwater. Lahontan Reservoir, located in the lower river, stores water for use in the state's agricultural oasis and large wetland complexes in the Lahontan Valley. In lower river reaches, water sinks into the ground, leaving dry reaches, as happens in many streams in Nevada. These wetlands, which are part of the Western Hemispheric Shorebird Reserve Network, provide vital feeding, breeding, and resting habitat for hundreds of thousand of migratory and resident birds.

Table 2-4. Major Reservoirs and Lakes of Nevada and Eastern California

Hydrographic Region	Lake/Reservoir	Surface Area	Active Storage Capacity	Total Storage Capacity
		acres	acre-feet	
Carson River	Lahontan Reservoir	14,600	317,000	317,000
Colorado River	Lake Mead**	158,000	26,200,000	29,700,000
	Lake Mohave**	28,000	1,810,000	1,820,000
Humboldt River	Pitt-Taylor Reservoir, Lower	2,570	22,200	22,200
	Pitt-Taylor Reservoir, Upper	2,070	24,200	24,200
	Rye Patch Reservoir	11,400	171,000	171,000
	South Fork Reservoir	1,650	40,000	40,000
Snake River	Wild Horse Reservoir	2,830	73,500	73,500
Truckee River	Big and Little Washoe Lakes	5,800	14,000	38,000
	Boca Reservoir**	980	40,870	41,110
	Donner Lake**	800	9,500	no report
	Independence Lake**	700	17,500	no report
	Lake Tahoe**	124,000	744,600	125,000,000
	Martis Creek Lake**	770	20,400	21,200
	Prosser Creek Reservoir**	750	28,640	29,840
	Pyramid Lake*	111,400	NA	21,760,000
	Stampede Reservoir**	3,440	221,860	226,000
Walker River	Bridgeport Reservoir**	2,914	40,500	40,500
	Topaz Lake**	2,410	61,000	126,000
	Walker Lake*	33,500	NA	2,153,000
	Weber Reservoir	950	13,000	13,000

Source: Nevada Division of Water Planning, 1999.
Note: *Pyramid and Walker Lakes are natural terminal lakes with no outlet. **Located entirely or partially in California. Active storage capacity means the amount of water that can be released from the lake or reservoir. Total storage capacity is the total amount of water held in the lake or reservoir. All data as of 9/30/96.

The **Colorado River** is the largest river in Nevada, receiving water from many western states, including Wyoming, Colorado, Utah, New Mexico, Arizona, California, as well as Nevada. Along its 1,400-mile course to the Gulf of California, the Colorado River Basin drains an area of about 240,000 square miles – about one-twelfth the area of the contiguous United States. The Colorado River and tributaries in Nevada (i.e., Muddy, Virgin, and White rivers) provide a majority of the drinking water supply to the Las Vegas area, hydroelectric power and recreation opportunities at Lake Mead and Lake Mohave, and water for agriculture. Nevada receives a 300,000 acre-feet annual allotment of the river's water under the Colorado River Compact, the smallest portion among the seven states and Mexico. Fortunately, Las Vegas is located close to Lake Mead so southern Nevada water utilities can economically pump from the Colorado River system to meet municipal and industrial needs. Nevada is allowed a "return-flow" credit for all water returned to Lake Mead. Water treated and returned to Lake Mead is accounted for and Nevada has "earned" as much as an additional 151,000 acre-feet annually in return-flow credits.

The **Humboldt River** is the longest river entirely within Nevada. The Humboldt River originates in the Ruby, East Humboldt, Independence, and Jarbidge Mountains and flows 310 miles westward to terminate in the Humboldt Sink. Higher elevation watersheds north and south of the main stem feed seven tributaries that help sustain flow. A majority of the Humboldt River system water is used for agriculture. There are only a few flow-regulating reservoirs in the basin, the largest (Rye Patch Reservoir) being near the end of the system. Extensive reaches of the lower half of the river lose water to the ground and also evaporation. As a result, late season irrigation water shortages are commonplace throughout much of the area above Rye Patch Reservoir.

The **Truckee River** begins at a modestly sized dam located at the northern end of Lake Tahoe, in California. It flows down a narrow, winding canyon until the channel enters the Truckee Meadows where the cities of Reno and Sparks are located. The 145 mile long river terminates at Pyramid Lake (California Department of Water Resources, 1991(b)). Pyramid is one of only two sizable lakes surviving the desiccation of ancient Lake Lahontan. With numerous upstream reservoirs, mostly in California, the Truckee River is the most regulated river system in Nevada (Figure 7). Along its course, water is diverted to meet the needs of municipal and industrial, agricultural, and hydropower users. In response to greater use and dependency on Truckee River water, a new river operating agreement is being prepared. The Truckee River Operating Agreement is intended to provide modified operational criteria of reservoirs to conserve the endangered and threatened fishes of Pyramid Lake (i.e., cui-ui and Lahontan cutthroat trout) and to provide for future municipal and industrial water demands during droughts (U.S. Bureau of Reclamation, 1998). A portion of the Truckee River flow is diverted at Derby Dam and then conveyed via canal to Lahontan Reservoir in the Carson River Basin. Reservoir water is distributed to irrigate 50,000 to 60,000 acres in the Newlands Reclamation Project and large wetlands in Lahontan Valley.

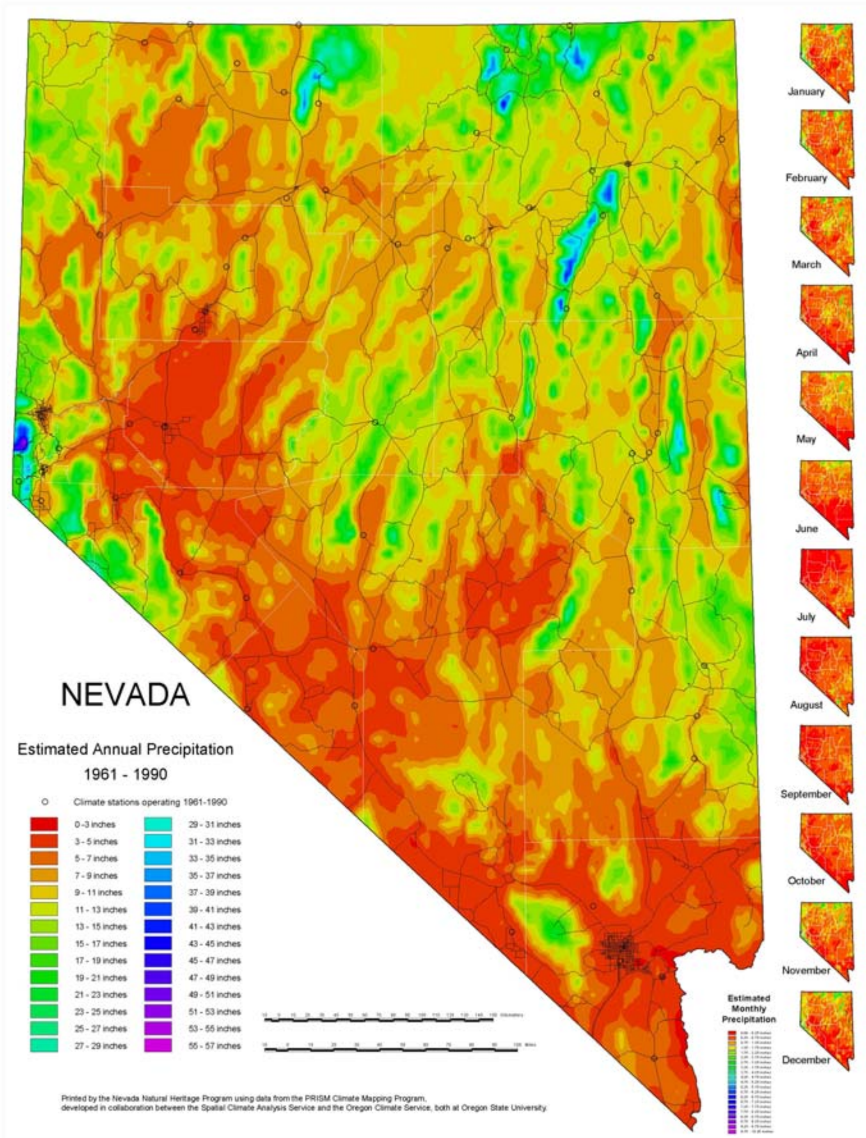
Like the Carson and Truckee, the **Walker River** rises in California. The river flows into Nevada through large irrigated valleys, the most prominent being Bridgeport and Antelope in California, and Smith and Mason in Nevada. The terminus is Walker Lake. Walker Lake is the only other surviving descendant of ancient Lake Lahontan, which covered 8,000 square miles in northern Nevada when mountain glaciers were melting and the climate was wetter several thousand years ago (California Department of Water Resources, 1992). Most of the Walker River streamflow originates in California and is used almost exclusively for a variety of agricultural uses in Nevada and California. The two largest reservoirs on the system are Topaz Lake, straddling the Nevada/California border, and Bridgeport Reservoir in California. Both are owned and operated by the Walker River Irrigation District to supply irrigation water to district members. Small lakes and reservoirs in the Sierra Nevada Range and nearby valleys help sustain stream flow into the autumn months during all but the driest years.

Climate

Climate factors that influence water resources the most are annual precipitation and evaporation. Statewide, total precipitation averages approximately nine inches per year, making Nevada the most arid state. Although the climate is generally characterized as semi-arid to arid, actually precipitation, evaporation, and other climate factors vary greatly. Figure 2-4 shows the large regional variation in average annual precipitation. Annual average precipitation ranges from three inches in the Mojave Desert region of southern Nevada to more than 40 inches (over 300 inches of snowfall) on Mount Rose in the Carson Range, near Lake Tahoe. Both elevation and latitudinal differences are causes for these extremes. Year to year and month to month, the amount of precipitation can fluctuate greatly. This variability creates uncertainty for irrigators, water suppliers, fish and wildlife managers, and stream flow forecasters. Factors contributing to unpredictable snow and rainfall patterns are seasonal variability in the approach of moisture-bearing storm fronts from the Pacific Ocean, and the rain shadow effect created by the Sierra Nevada Range along the state's western border as well as dozens of other high elevation mountain ranges.

Of the total annual precipitation falling in Nevada, on average less than 10 percent produces stream runoff or percolates downward to recharge aquifers. Nevada is desert-like, because on average, 90 percent of the moisture is returned to the atmosphere by evaporation and plant transpiration. Similar to the state's precipitation pattern, the rate of evaporation varies tremendously in time and space. Key

Figure 2-4. Average Annual Precipitation Patterns in Nevada



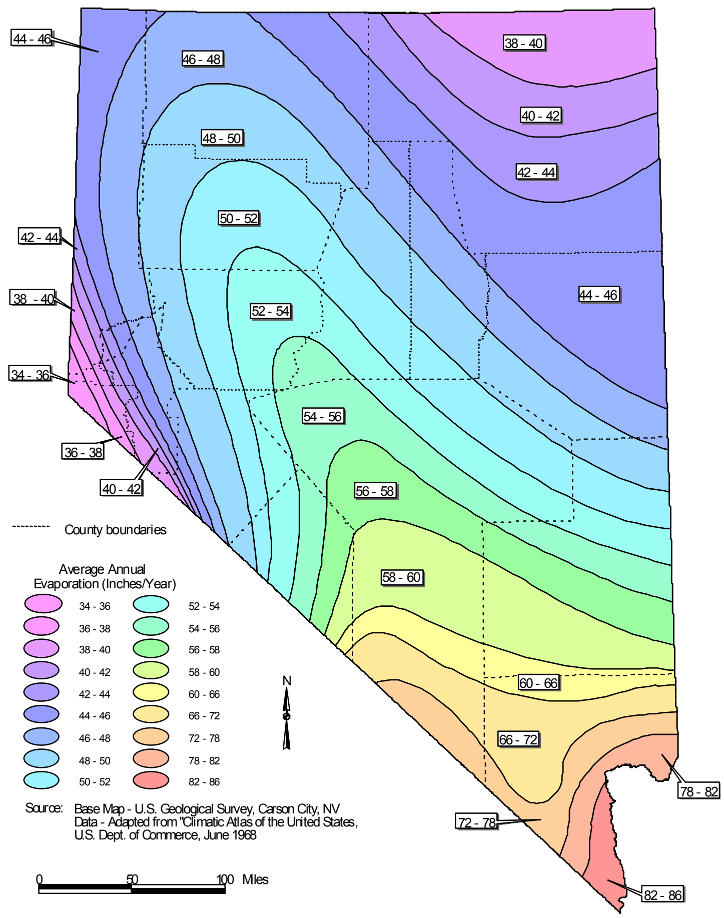
Source: This poster was compiled from estimated annual precipitation values calculated by the PRISM Climate Mapping Program at Oregon State University. The small side maps show estimated precipitation in each month. Also shown are the locations of climate stations that were likely used in the estimation calculations. Precipitation values are interpolated from estimates made on a 1 km grid.

factors are elevation, latitude, and the type and density of vegetative cover. Average lake surface evaporation rates range from less than 36 inches per year in the west to over 80 inches per year in the south (Figure 2-5). Droughts and floods are relatively common in our highly variable climate. Years of average stream flow occur rarely. Alternating periods of high and low flows are the norm in Nevada. Many water users cope with low stream flow in summer and autumn with supplemental sources, such as reservoirs and groundwater.

For most water users that rely principally upon surface water, problems can begin when below average flows are experienced for two or more consecutive years. Dry soil and hot weather conditions during a drought lead to higher watering requirements, especially on farmland, parks and golf courses, and urban landscaping. Increasing withdrawals from reservoirs and wells can result in depletion of the supplemental water sources. In water basins where surface and groundwater resources are fully committed, extended recovery periods for depleted supplemental sources may raise uncertainty in the short and long term water supply picture for some (junior) water rights holders as well as aquatic ecosystems.

Periods of drought (i.e., consecutive years with stream flow less than 80 percent of the annual average) are frequent in Nevada. In many cases, Nevada's river systems experience more "below average water years" than "above average water years". Five serious drought periods occurred during the Twentieth Century. The periods were 1928-37, 1953-55, 1959-62, 1976-77 and 1987-94. The 1928-37 period possibly was the most severe and longest in northern Nevada. The most recent drought was severe enough to effectively remind public water suppliers and agricultural operators of the limited nature of Nevada's water, as well as the environmental impacts of dry lakebeds and streams to fisheries, wildlife habitat, and air quality. Droughts can also create or aggravate water quality problems for both surface water and groundwater sources. Over time, lower flow and less groundwater recharge tends to diminish quality of the remaining water.

Figure 2-5. Average Annual Evaporation Patterns in Nevada



Source: Base Map by U.S. Geological Survey, Carson City, Nevada. Data from "Climate Atlas of the United States, U.S. Department of Commerce, June 1968.

Even though the average annual precipitation is only nine inches, floods are common and have occurred in all parts of the state. The intensity and damaging effects of floods in urban communities have increased steadily with population and development since the mid-1900s. Land development has encroached onto riverine and alluvial fan floodplains, decreasing floodwater storage capacity and increasing flood damage risk.

The most severe floods occur on the Truckee, Carson, Humboldt, and Walker rivers when warm winter rain falls on snow in the higher mountain ranges. Flash flooding from intense rainfall over relatively small areas is common in the larger, more sparsely vegetated watersheds of southern Nevada and on alluvial fans of smaller drainages throughout the state. Flooding from summer storms is typically sudden, and often life threatening. Rain-on-snow flooding along the major rivers usually takes many hours or days to develop, so time to prepare for flooding is available. However, peak flows and inundation extends over a longer period of time. In the Clark and Washoe county metropolitan areas where recent floods have seriously damaged lives and property, local government have developed regional flood control plans and programs and are actively working on controls to additional runoff generated by new development.

Interest is growing in retention and restoration of natural floodplain features and functions. An example is the development of the Truckee River Flood Management Plan, which started shortly after the devastating 1997 New Year's Day flood. In 1999, the Washoe County Board of Commissioners, with support of the cities of Reno and Sparks, the State Legislature, and local organizations, approved a 1/8-cent sales tax to be used for public safety and flood management in the Truckee Meadows region. The

Community Coalition for Truckee River Flood Management was formed to coordinates with the U.S. Army Corps of Engineers. The Coalition includes about 25 local stakeholder organizations, 15 agencies, and interested individuals. In addition to flood protection, this plan addresses restoration and preservation of the River's natural habitat, scenic beauty, recreational amenities, and other environmental resources. Flood management concepts will be based on the natural processes and characteristics of the river.

Groundwater

Careful management of groundwater, the state's long term water supply source, is vital to economic and ecological sustainability. Hydrologists estimate that three to seven percent of the average annual precipitation recharges groundwater systems. Surface water resources are essentially fully appropriated, so new development projects often tap into groundwater sources or seek to transfer existing surface or groundwater rights. Groundwater provides about 40 percent of the total water supply used in Nevada. Groundwater is the sole supply source in some regions.

Twenty-eight percent of the state's municipal and industrial water needs are met with groundwater (Nevada Division of Water Planning, 1999). However, the amount of groundwater used can vary considerably each year. More new groundwater wells are being constructed to supplement surface water sources. During periods of low streamflow, groundwater use increases, and conversely, decreases during high flow periods.

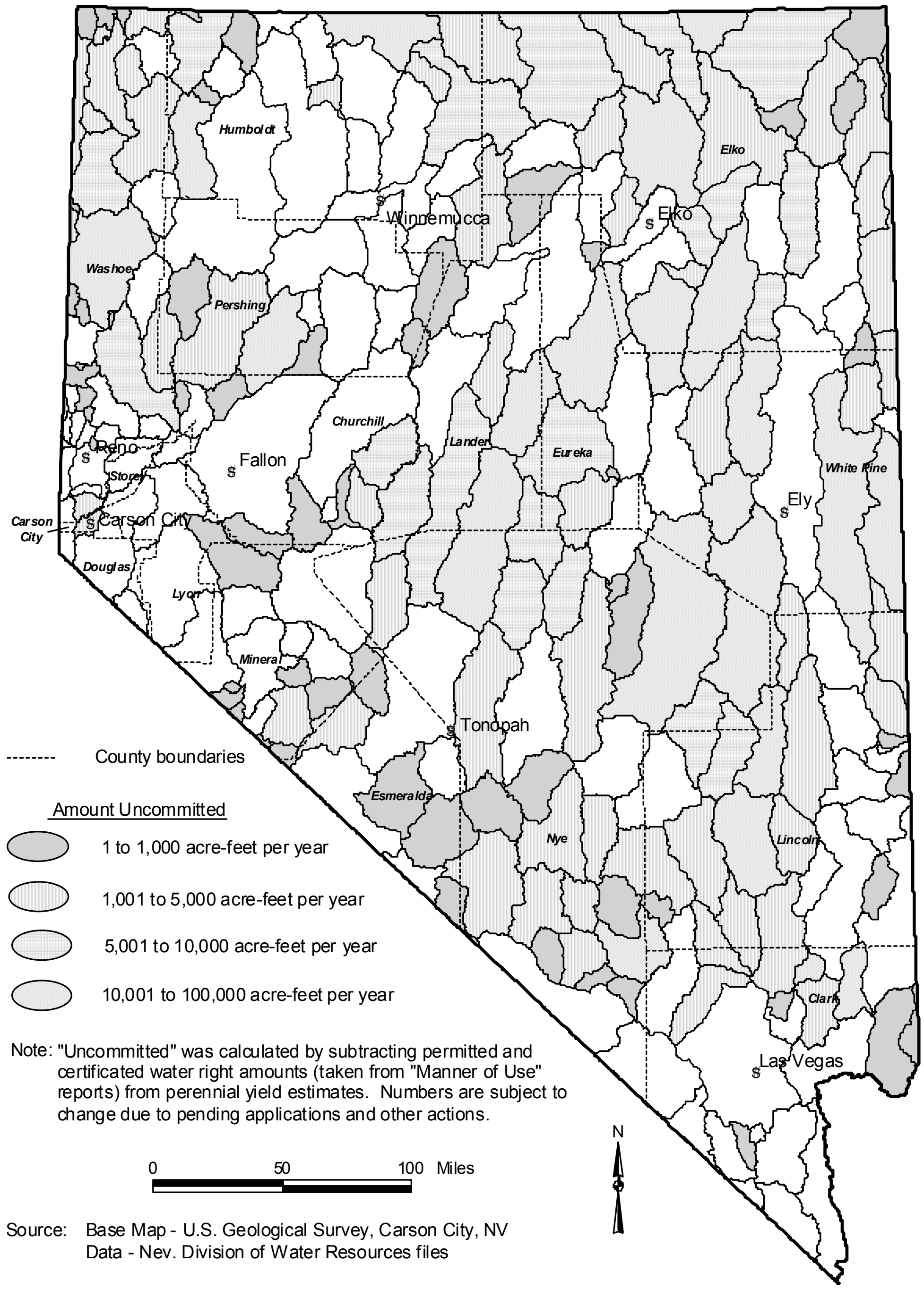
Proper planning and management of groundwater resources grows in importance as more communities and industries come to depend on this finite resource. Because the state's population and economy is projected to continue to rapidly grow, greater scientific understanding of groundwater conditions will be essential. Particularly, greater knowledge is needed in aquifer location, refined perennial yield, recharge, storage volume, committed resources (water righted amounts), actual water use, water levels, water quality, and projected trends.

Forty years ago, the Nevada Division of Water Resources (NDWR) and the U.S. Geological Survey (USGS) recognized the need for a systematic identification of the states "hydrographic areas". A cooperative groundwater program was initiated to study, research, develop, manage, and administer groundwater and surface water systems. A product is the 1968 hydrographic unit map, the first systematic delineation of all hydrographic regions and areas. With minor revisions, the 1968 map continues as the basis for water planning, management, and administration. The current map delineates 14 hydrographic regions subdivided into 256 hydrographic areas (HA's) (Figure 2-6). Another result of the cooperative program was reconnaissance level estimations of perennial yield for each HA.

Perennial yield is the estimated volume (acre feet) of usable water in a groundwater basin or aquifer that can be economically withdrawn and consumed each year for an indefinite period without depleting (mining) the source. The State Engineer uses perennial yield estimates as the baseline to compare total committed groundwater allocations to water available in the system, or uncommitted resources (Figure 2-6). Technically, the calculation method subtracts the amount of water evaporated and transpired (i.e., water vapor from plants) from the amount that may be appropriated. Basins include one or more aquifers, or water-filled cracks, joints, and pores in consolidated volcanic, granitic, or sedimentary rock formations or thick, unconsolidated valley sediment deposits formed by upland erosion. Some aquifers in Nevada contain water recharged thousands of years ago under much wetter climate conditions. Recharge rates under current conditions are much lower. If over-pumped, groundwater levels may be irreparably lowered.

According to the cooperative studies performed by the State Engineer and the USGS, the statewide perennial yield totals about 2.1 million acre-feet per year (Nevada Division of Water Planning, 2001a). "Committed resource" refers to the total volume of groundwater rights that the State Engineer officially recognizes and that usually can be withdrawn from a basin each year (Figure 2-7). In 1995, groundwater withdrawals total approximately 1.6 million acre-feet statewide. Of the quantity of groundwater pumped, about 0.7 million acre-feet used consumptively.

Figure 2-6. Estimated Uncommitted Groundwater Resources for Hydrographic Units (acre feet per year)



Note: "Uncommitted" was calculated by subtracting permitted and certificated water right amounts (taken from "Manner of Use" reports) from perennial yield estimates. Numbers are subject to change due to pending applications and other actions.

Source: Base Map - U.S. Geological Survey, Carson City, NV
Data - Nev. Division of Water Resources files

Figure 2-7. Estimated Committed Water Resources for River Basins and Hydrographic Regions (acre feet per year)

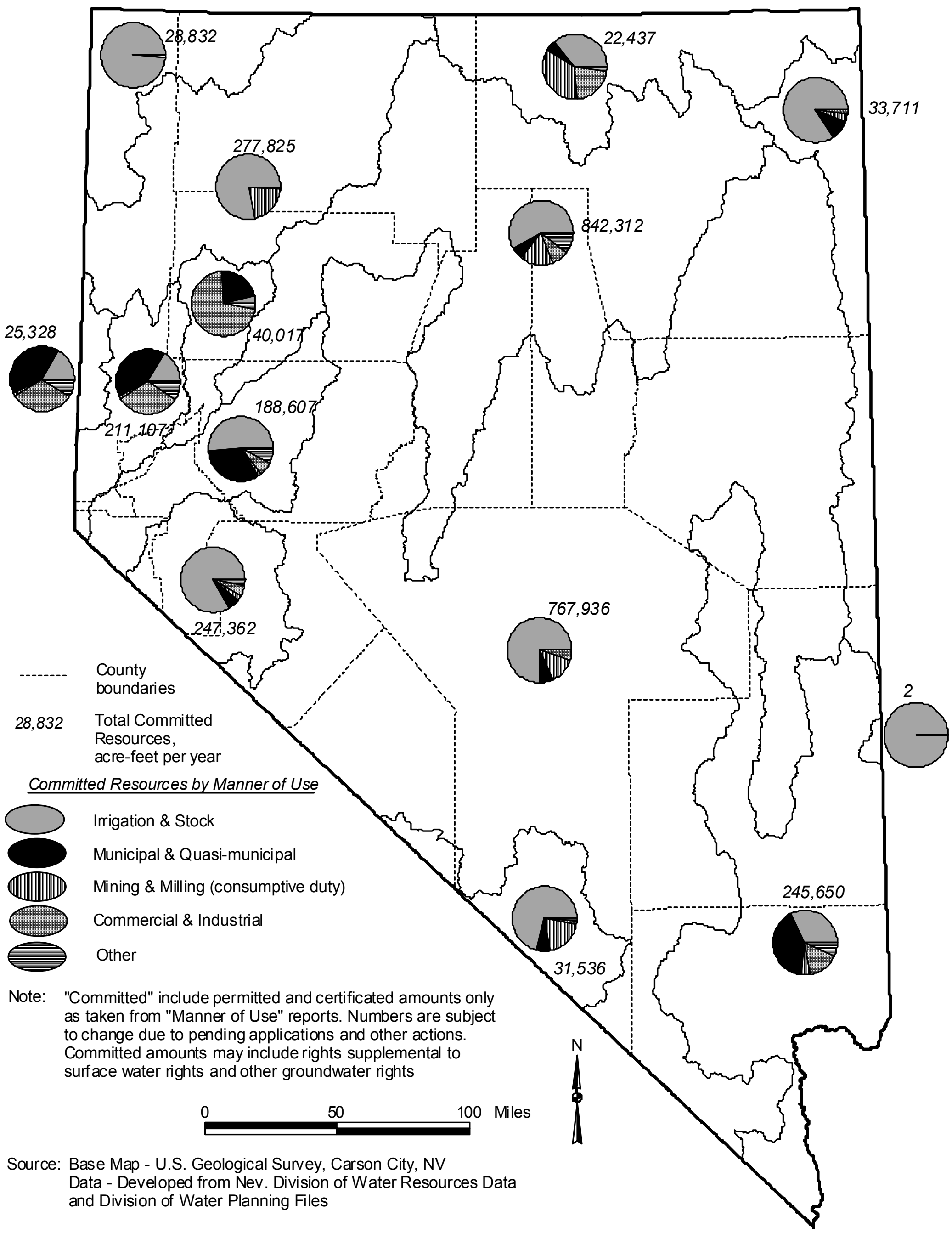
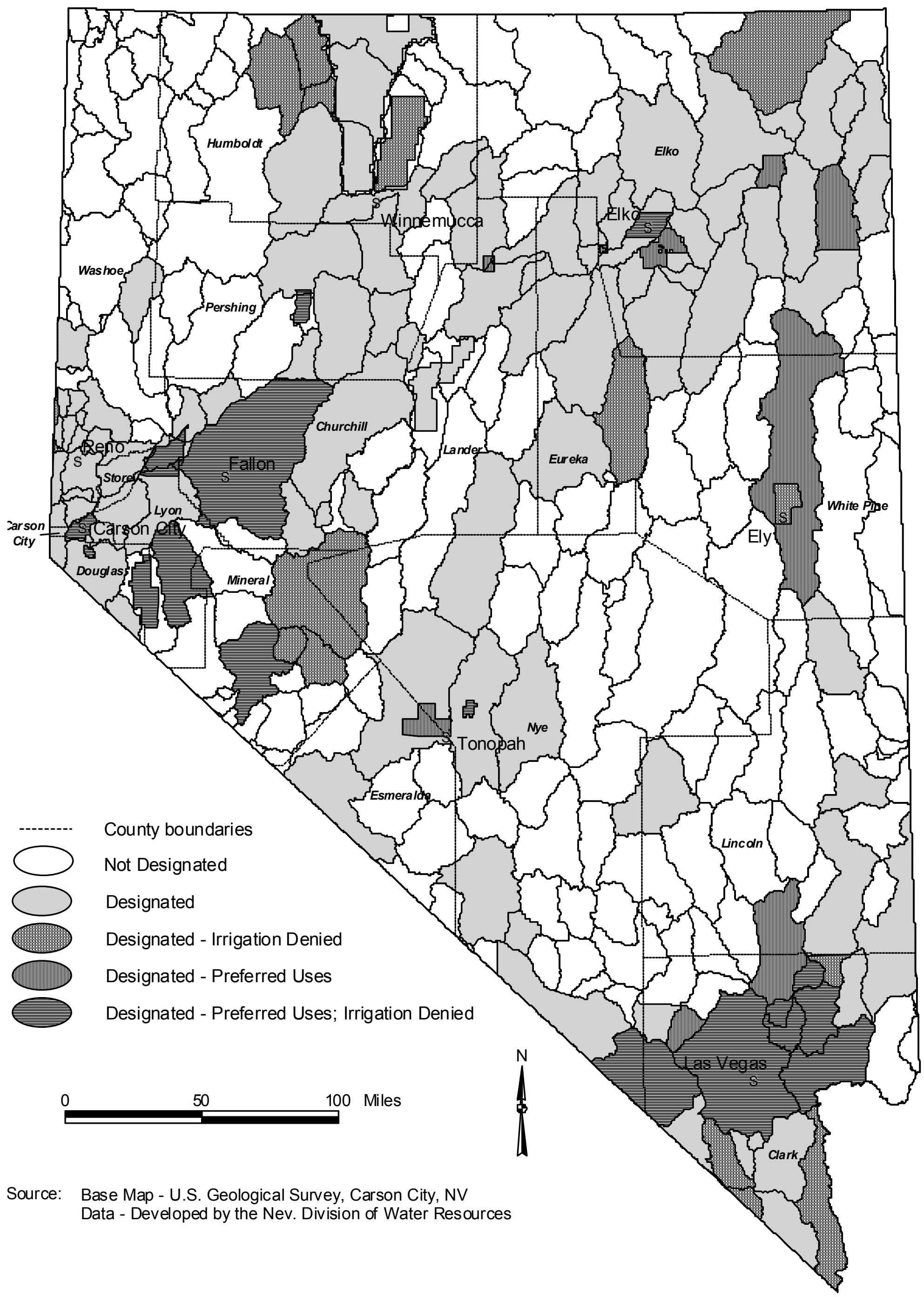


Figure 2-8. Non-Designated and Status of Designated Hydrographic Units in Nevada



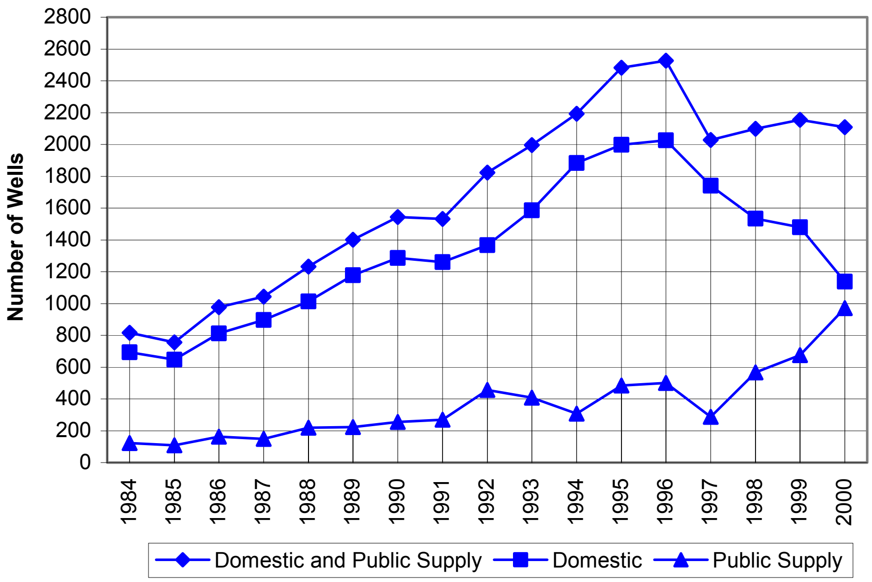
Source: Base Map - U.S. Geological Survey, Carson City, NV
Data - Developed by the Nev. Division of Water Resources

When making determinations on groundwater right applications, the State Engineer considers the individual and regional perennial yield estimates, system yield estimates, and committed resources, among other factors. Committed volumes of water remain lower than perennial yield in about 60 percent of the 256 basins. The state's un-appropriated groundwater supplies are located in these basins. The State Engineer has increased administrative efforts in many of the groundwater basins where demand for groundwater supplies has grown. The State Engineer has authority to "designate" a groundwater basin that is being depleted or requires additional administration to make sure important local uses of the aquifer(s) can be sustained. By issuing an order of designation, the State Engineer is granted additional authority to make special administrative decisions regarding groundwater resources.

For example, the State Engineer may issue orders that define preferred uses, deny certain water uses, or curtail pumpage. Preferred uses may include domestic, municipal, quasi-municipal, industrial, irrigation, mining and stock-watering uses or any other beneficial use. Each basin is managed as a separate unit. The State Engineer issues orders and rulings, as needed for the management of the groundwater resources. Figure 2-8 displays the "designated basin" status for the 256 hydrographic units. This map is a useful tool to generally determine where the greatest impediments to groundwater development may exist. However, the associated State Engineer's orders and rulings need to be examined for a complete understanding of the management issues and water availability within a basin.

The number of new well logs filed each year gives some indication of the intensity of groundwater development. Figure 2-9 shows the trend in the number of new domestic and supply wells drilled each year since 1984. In 1984, 817 wells were drilled. Since the peak year (1996) when 2,527 wells were drilled, activity has leveled off, ranging between 2,028 and 2,155 each year. Wells drilled for other purposes, such as geothermal production, monitoring, and mineral or future water supply exploration, are not included. The increased well construction activity for domestic and public supply is greatest in areas experiencing rapid growth (i.e., northcentral, northwestern, and the southern regions).

Figure 2-9. Number of Domestic and Public Supply Wells Drilled in Nevada, 1984 to 2000

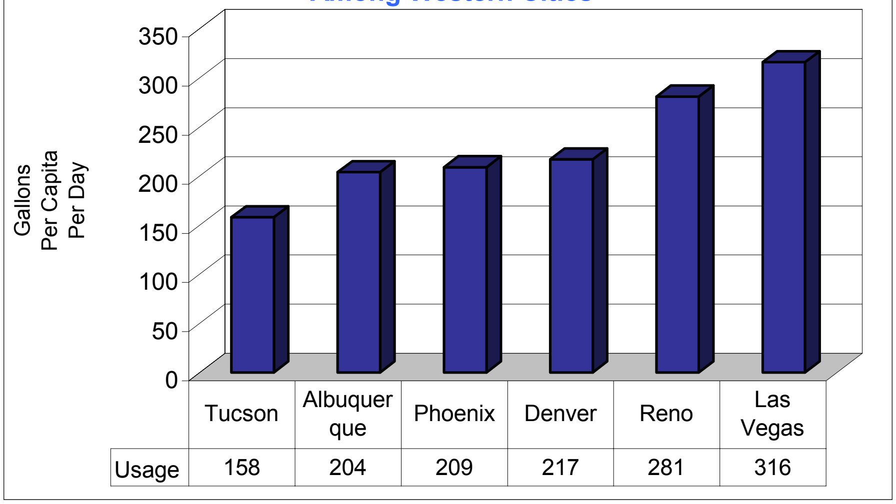


Source: Nevada Division of Water Resources, Well Log Database, 2001.

Water Supply for Future Needs

Meeting our future water needs will require implementation of a combination of strategies. Two basic strategic approaches are demand management and supply development. Through demand management, water purveyors make wiser use of the available water thereby lessening the need for new source development. Supply development strategies include a variety of methods for increasing supplies and improving supply reliability. Increasing demands and competition for our limited resources oblige water managers and suppliers to implement both demand management and supply development strategies. However, each option needs to be evaluated on a case-by-case basis for suitability, cost effectiveness, and public acceptance.

Figure 2-10. Comparison of Water Usage Among Western Cities



The time is past when water supply needs can be met simply by developing more water withdrawal, storage, and delivery systems. Demand management must also be part of any long-range water supply plan. By reducing demand, new supply developments can be delayed with potential savings to the users. Demand can be managed through conservation measures and alternate strategies such as effluent reuse, grey water use and dual water systems. Figure 2-10 compares the average amount of water used per person per day in cities in Nevada and other western states. Though urban water utilities and local governments encourage conservation through tiered pricing, limited landscape watering days, and low-volume appliances, the data suggest that there is room to improve upon conservation and other demand management strategies. However, a direct comparison of average water use between cities must consider different climate and water supply circumstances. For example, other cities receive summer rains or use other water sources for lawn watering, thereby reducing public supply system water use.

Even as more effective demand-side strategies evolve, water supply development strategies also need to include methods for increasing supplies and improving reliability. The supply-side strategies described below may not be appropriate in all situations and must be examined on a case-by-case basis.

- Use of existing committed and uncommitted supplies refers to water suppliers that further utilize supplies under their existing water rights and/or obtain new appropriations for unallocated water.
- Water transfers involving a water rights purchase or lease from one user for use by another.
- Groundwater recharge and recovery or artificial aquifer recharge, is a water resource management option available to some areas as a means of securing more reliable water supplies during periods of low surface water flows. This strategy involves ponding or injecting surface water when abundant, to enhance aquifer recharge for later use. State water law provides criteria for establishing groundwater recharge/recovery programs. Currently, the State Engineer's office has sixteen (16) recharge applications and permits on file, with a total potential recharge of 93,709 acre-feet per year.
- Conjunctive use, in which different supply sources (e.g., surface and groundwater) are used in combination or in alternating periods, depending upon the relative abundance of each. When surface water supplies are abundant, excess is stored in aquifers, and groundwater use curtailed, optimizing natural recharge. Conversely, when surface supplies are low, stored surface water and recharged groundwater can be used to make up for limited surface water supplies.
- Desalination requires the use of a processing plant to remove dissolved minerals (including but not limited to salt) from seawater, saline water, or treated wastewater.
- Cloud seeding is a weather modification technique involving the injection of silver iodide or other compound into clouds to increase precipitation. The estimated additional amount of water obtained each year has varied from 35,000 to 60,000 acre-feet during the 1990's.
- Reclamation or restoration of deteriorated watershed conditions to reduce surface runoff and enhance groundwater recharge conditions, and by land use planning considerate of the relationship between water resources and development patterns.

Efforts to raise Pyramid Lake water level exemplify the types of water management strategies that are essential in our desert region. Since 1981, the lake level has risen about 30 feet, recovering a portion of the 80-foot decline that occurred in the first half of the 1900's. Though most of the recent increase came during wet winters in the Truckee River watershed, modified supply strategies and use practices have helped to deliver more water to the lake and stop further lake declines during drought years. Measures include: conjunctive use of the Carson and Truckee River to meet agricultural water supply requirements in Lahontan Valley; identification and curtailment of non-essential uses; conservation measures implemented by farmers in the Truckee Carson Irrigation District and residents and businesses in Reno and Sparks; and, the transfer of water rights to maintain higher river water quality during droughts.

In southern Nevada, innovative management strategies are being used to secure water from the Colorado River for the growing population and economy in Clark County. Water suppliers and government agencies have worked out agreements that permit Nevada to store a portion of the state's share of Colorado River water in Arizona aquifers. Southern Nevada water suppliers will be able to draw a proportionate amount of water from the river and Arizona will have access to the groundwater for future use. Growing water demand and diversification of water uses is occurring in numerous other water basins (e.g., Carson Valley and Walker Lake). Each presents unique opportunities to develop creative supply and demand strategies that add value to the water resources for all Nevadans.

Small mountain reservoirs, such as Hobart Reservoir in the Carson Range of western Nevada, can provide important benefits. For example, Hobart is located at a higher elevation and situated in a sheltered valley, a situation that reduces evaporative losses during the summer. By detaining a portion of the year's snowmelt, the reservoir yields drinking water supply, sustains late summer stream flow, adds to the diversity of plant and animal communities, provides fishing opportunity, and enhances scenic value.

Water for Instream Use

Balancing "off stream" uses of water with "instream" uses always will present challenges in this arid region. When the state legislature officially adopted the prior appropriation doctrine, a diversion was a key to claiming a water right. Since then Nevada Supreme Court has determined that state water law gives the State Engineer discretion to grant a water right for instream flow or to maintain a minimum pool in lakes and reservoirs. Though a portion of the water diverted gets returned, water conditions gradually become less hospitable to native plants and animal species further downstream due to annual and seasonal depletion of surface waters and deterioration of water quality. Many native fish species no longer inhabit state waters, and more are classified threatened or endangered. Relatively few water rights, however, have been acquired for instream uses. Ironically, urban population growth and economic growth appears to correspond with heightened public interest in improving instream water supplies. Improvements in water quality, water-based recreation, aquatic habitats, and scenic quality are some of the benefits various interests seek to gain or protect on behalf of the public.

In recent years, agencies, conservation organizations, and some local governments have shown interest in acquiring water rights from willing sellers to retain more water in streams, reservoirs, and wetlands for environmental, biological, and recreational purposes. Often, the opportunity to acquire water rights and transfer the beneficial use for instream uses arises as property owners convert private agricultural land to another land use, such as urban, commercial, or industrial development. The sustainability of farming and ranching in downstream rural communities is an important consideration. Most of the water planning and acquisition activity has occurred in the Truckee and Carson River basins to improve water quality, stream flow conditions, fisheries at Pyramid Lake, and wetlands in Lahontan Valley. Water rights have been acquired for some state Wildlife Management Areas and other locations (e.g., Meadow Valley Wash, Upper Blue Lake, and the Bruneau River) (Division of Water Planning, 1999b). State agencies involved with instream water rights include the Divisions of State Lands, Wildlife, and Water Resources.

Surface and Groundwater Quality

Surface Water Quality

Water quality standards define water quality goals of rivers and lakes in Nevada. Standards are set and revised through a regulatory process that starts with detailed analysis and a proposal by NDEP, which must be adopted by the State Environmental Commission. Two types of standards are in use. One type is the general "narrative" standard, assigned to all water bodies in the state to set a minimum level of protection. In addition, detailed "numeric" standards have been set for major rivers, streams, lakes, and reservoirs. The latter take into account specific chemical and physical conditions necessary to maintain designated beneficial uses (e.g., drinking, swimming, fishing, and industrial processes). Stream reach specific numeric standards have been developed for water bodies in the Carson, Colorado, Humboldt, Snake, Truckee, and Walker River Basins and many smaller streams.

To ensure standards are being maintained, the NDEP periodically monitors water quality in 80 river reaches and 10 lakes and reservoirs. Water bodies identified in the agency's Water Quality Monitoring Plan are sampled 3 to 12 times each year. The state's surface water monitoring network was established in 1967. Modifications are periodically made based on review of the database, resource constraints, and opportunities to coordinate and utilize other government agencies monitoring activities. The monitoring network is used to assess compliance with water quality standards, conduct trend analysis, validate water quality models and set total maximum daily loads (TMDL's). The data also is used for nonpoint source assessments, the 303 (d) List, 208 Plan Amendments, and the 305(b) report.

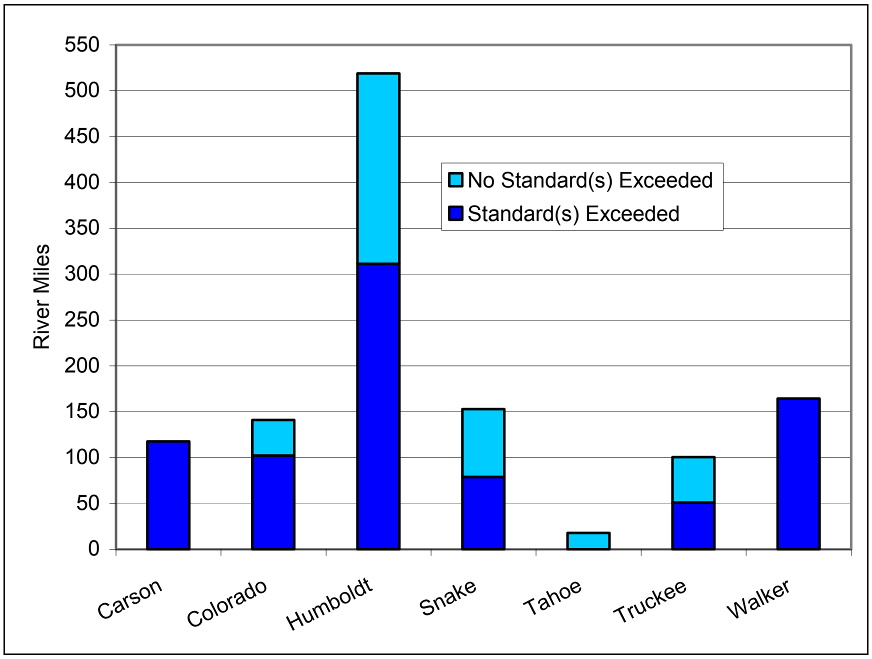
Selection of the more than 100 sampling sites in the monitoring network is based on land use intensity, water quality, hydro-modifications, and topography. Samples are analyzed for nutrients, sediment, metals, temperature, dissolved oxygen, pH, and other chemical and physical parameters. In general, if twenty-five percent of the samples for a pollutant exceed the water quality standard, then the water body may be classified as impaired. Impaired water bodies placed on the Clean Water Act 303(d) List. The 303(d) List is intended to draw more attention to water bodies in need of water quality improvement. A new listing will be published by NDEP in 2002, incorporating new methods of determining impairment.

Beginning in Summer 2000, the NDEP began a preliminary bio-assessment monitoring program to supplement physical and chemical quality assessments. The bio-assessment monitoring involves investigation of the presence of macro-invertebrates (i.e., insects, such as stone, caddis, and mayfly larvae), channel shape and dimensions, flow conditions, and riparian plant cover. Fifty initial sampling sites were established on the Truckee, Carson, and Walker rivers. In 2001, additional bio-assessment sampling sites will be established on the Muddy and Virgin rivers, and tributaries of the Humboldt.

River Water Quality Status

A summary of the water quality status of major rivers in Nevada and streams tributary to Lake Tahoe is shown in Figure 2-11. All rivers, except streams flowing from the Nevada side of Lake Tahoe, show slight to serious signs of impaired water quality in a number of reaches. Each receives runoff from land developed for urban, industrial, mining, and/or agricultural uses. Of 1,213 river miles periodically assessed, water quality standards were not met for one or more pollutants on 825 miles (Nevada Division of Environmental Protection, 2001a). Nutrients, sediment, and metals are the most widespread pollutants contributing to exceeded standards (Table 2-5).

Figure 2-11. Water Quality Status of Major Rivers in Nevada Measured in River Miles, 1996 and 1997.



Source: *Nevada's Revised 1998 Section 303(d) List*. Nevada Division of Environmental Protection. January 2001.
Note: "Tahoe" refers to streams monitored on the Nevada side of Lake Tahoe Basin.

Phosphorus is the most widespread nutrient found at elevated levels. Human sources are probably fertilizer use and animal feedlots. However, many soil types and rock formations are naturally phosphorus rich. Historic mining and milling activities, as well as natural sources, such as metal-bearing rock formations and geothermal springs, are associated with high metal levels in monitored water bodies in addition to various others located throughout the state. Abandoned mine land (AML) sites that are or have the potential to degrade water quality are numbered in the thousands according to a report produced by the U.S. Bureau of Land Management (BLM) and the Nevada Division of Mines (NDOM) as part of a federal-state task force. The Task Force identified and prioritized AML sites where contamination is present or possible. Thirty-three priority reclamation sites are identified in the *Nevada Abandoned Mine Lands Report* (Interagency Abandoned Mine Land Environmental Task Force, 1999).

Water quality standards exceeded on other water bodies also include boron in reaches of the Humboldt and Colorado rivers; suspended solids, or sediment, in the lower Walker and lower Truckee rivers; and, mercury in the Carson River, below Carson City. The elevated nutrient level in the Truckee River occurred below the outfall from the Truckee Meadows Water Reclamation Facility. Operational improvements and more stringent permit limits have lowered the amount of nitrogen in the discharge. More recent water quality data show the total nitrogen

Table 2-5. Common Pollutants Causing Sub-standard Water Quality by River Miles, 1996 and 1997

River	Nutrients	Sediment	Metals	Total Miles Assessed
Carson	114	80	53	118
Colorado	42	0	12	141
Humboldt	290	290	311	519
Snake	30	30	17	153
Tahoe	0	0	0	18
Truckee	51	46	0	100
Walker	88	96	30	164
River Miles	615	542	424	1,213

Source. *Nevada's Revised 1998 Section 303(d) List*. Nevada Division of Environmental Protection. January 2001.

standard is being met. Where mercury or other toxic metals reach levels in fish that could pose a threat to human health, the state Heath Division issues advisories. The only fish consumption advisory in the state is the result of mercury in the lower Carson River, below the historic Comstock-era mill sites.

An indication of low pH and high concentrations of heavy metals in surface water is the presence of orange iron oxyhydroxide, often associated with acid mine drainage. This water quality condition also occurs naturally by weathering of altered rock in association with subsurface water. The photo shows a streambed next to a tailing pile at the Rio Tinto Mine in Elko County. A remediation plan has been developed for the mine site. 1995. Courtesy of Jon Price, Nevada Bureau of Mines and Geology.

The process to identify water quality improvement measures for the purpose of attaining the standard(s) begins with establishment of the Total Maximum Daily Load (TMDL). A TMDL is equivalent to calculating a budget for pollution. In the TMDL process, scientists estimate the total amount of a pollutant that could be released by all point and nonpoint sources to a specific water body without exceeding the beneficial use standards. After pollution sources are identified, the NDEP works with local government and interested parties to allocate pollution reduction responsibility.

The TMDL process has been implemented on several water bodies. Included are: 1) total phosphorous in seven segments of the Carson River; 2) total suspended solids in two segments of the Walker River; 3) total nitrogen, total phosphorous, and total dissolved solids in a segment of the Truckee River; 4) total phosphorous and total suspended solids in three segments of the Humboldt River, and total dissolved solids in two segments; and, 5) total phosphorous and total ammonia in Las Vegas Wash and Bay. Priorities for TMDL review and revision include the Las Vegas Wash and Bay, Humboldt River, and Walker River.

Because discharges from wastewater treatment plants, industrial facilities, mines, and other large point sources are regulated and monitored, much is known about the types and amount of pollution released. For most rivers in Nevada, all point source discharges have been removed. Nonpoint sources are the major causes for substandard quality in Nevada's impaired water bodies. Pollutant discharges from nonpoint sources are much more difficult to assess and control.

Nonpoint pollution is associated with serious impacts to native and endangered fishes, accelerated ageing of lakes (eutrophication), increased drinking water treatment requirements and costs, and general unsightliness that lowers scenic value, especially important to recreation-based tourism. In urban areas, runoff from streets and parking lots, construction sites, lawns and golf courses, and eroding channels contribute to elevated nutrients, heavy metals or sediment loads. In rural areas, nonpoint sources include intensive agricultural activities, irrigation, abandoned mine sites, and unpaved roads, eroding channels and barren stream embankments. Artificially low streamflow or lake levels and loss of wetlands and riparian plant communities can amplify the affects of nonpoint source pollution.

Lake and Reservoir Water Quality Status

Nevada contains 131 publicly owned lakes and reservoirs. Of these, 21 are of a significant size and account for 94 percent of the total lake surface area in the state. According to Nevada's 1998 Water Quality Assessment 305(b) Report, sixteen (16) of the larger lakes have high enough quality to be categorized as fully supporting all current beneficial uses. Some water quality parameters for Lake Tahoe, Topaz Lake, Lahontan Reservoir, and Las Vegas Bay (Lake Mead) indicate water quality is impaired, but still supports most beneficial uses (Nevada Division of Environmental Protection, 1998a).

Because Walker Lake, a desert lake at the terminus of the Walker River, contains high levels of dissolved salts and seasonally low oxygen levels, it has been classified in the state's 305(b) Report as not supporting beneficial uses. Primarily, the lake provides habitat for Lahontan cutthroat trout (LCT) fisheries and a variety of migratory and resident birds, as well as various water-dependent and wildlife related recreation activities. Upstream consumptive uses have reduced the amount of water reaching the lake. A long term lowering of the lake level is the major factor for episodes of degraded water quality that imperils aquatic life, including fishes. Concern over the Walker Lake ecosystem remains high.

Monitoring for Toxic Substances

The NDEP and the state Department of Agriculture, as well as federal agencies periodically sample water bodies to test for the presence and levels of toxic contaminants. The 1998 U.S. Geological Survey (USGS) report, *Water Quality in the Las Vegas Area and the Carson and Truckee River Basins*, describes the occurrence of toxic contaminants (e.g., metals, pesticides, uranium) in surface water bodies in the most populated areas of the state. Between 1992 and 1996, water samples were collected above and below areas with intensive agricultural, mining, and urban land uses in the Truckee and Carson River basins and Las Vegas Valley (Colorado River system). Samples also were collected in areas of known natural sources of contaminants.

In general, contaminants were present below areas of intensive land use, but usually at low levels. High arsenic concentrations were found in samples taken from Steamboat Creek, a Truckee River tributary, and agricultural drain water in the Carson Desert. Also, according to the USGS report, high uranium concentrations were found in samples taken from Las Vegas Wash and agricultural drains in the Carson Desert.

Geothermal systems in the Reno-Sparks and the Carson Desert were found to contribute arsenic, boron and mercury by way of springs and shallow water-table aquifers connected to surface waters. Elevated mercury in the Truckee River sediments occurs below Steamboat Creek. Steamboat Creek transports mercury and other metals from both naturally occurring and man-made sources associated with geothermal and mineral resources. The sediments of the Carson River below Carson City contain high levels of mercury, most originating from the processing of Comstock-era ore along the river between Dayton and Carson City.

Pesticides occurred in surface water samples taken downstream of all urban and agricultural areas, but at levels below the safe drinking water standards. Many samples contained detectable levels of more than one type of pesticide. Samples collected above urban and agricultural areas produced only one sample with one type of pesticide detected.

Groundwater Quality

Ground water resources in Nevada are precious. Cleaning up groundwater once contaminated is extremely costly and can take years. Before beginning activities that could contaminate groundwater, a permit must be obtained from the Bureau of Water Pollution Control. Strict regulations require implementation of preventative measures and monitoring. Preventative measures include holding tanks, impermeable liners, wastewater pretreatment, and using products or processes that do contain fewer or no potential contaminants. Monitoring helps identify undesirable water quality changes and prevent larger problems.

Because the purposes for monitoring groundwater quality vary, responsibilities are divided among different agencies. The Bureau of Health Protection Services, part of the Nevada Health Division, monitors aquifers tapped to supply public water systems. The Nevada Department of Agriculture (NDOA) shares responsibility for pesticides monitoring with NDEP. In addition, NDEP monitors groundwater quality through a permit program for facilities and activities that discharge, or may discharge, pollutants to groundwater. An important federal partner is the U.S. Geological Survey (USGS). The USGS conducts special studies and long term monitoring programs, often in conjunction with state agencies.

Monitoring is critical because early warning of changes in quality can avoid decades of treatment or abandonment of aquifers. Declining quality can result from natural, man-caused, or a combination of natural and human sources. Natural pollutants of concern include arsenic, radon, total dissolved solids, and metals. Certain land disturbing activities may disturb geologic or soil formations and mobilize natural contaminants, such as mining sulfide rich metal deposits, or concentrate them in specific areas, such as irrigation drain water. Problematic groundwater contaminants are released from residential, agricultural and industrial sources. Contaminants of greatest concern include pesticide/herbicide contamination, solvents and petroleum products, radioactive materials, metals, dissolved salts, and nitrogen.

Like surface water, the biggest groundwater quality protection challenges derive from less obvious, widespread pollution sources. Numerous diffuse sources of petroleum chemicals, solvents, metals, nutrients, dissolved salts, pesticides and pathogenic bacteria occur in urban, suburban, farming, mining, and industrial areas. In general, higher groundwater quality occurs in rural areas and lower quality in urban and suburban areas. The most frequently encountered mineral contaminant is nitrates, typically associated with high septic tank density, concentration of livestock in feedlots or low-density subdivisions, and fertilizer application for turf and certain crops. Solvents, such as perchloroethylene (PCE), and gasoline byproducts are the most common chemical constituents in degraded groundwater. Federal and state underground storage tank replacement and monitoring programs have greatly reduced the likelihood of leaks, thereby reducing accidental spills.

Groundwater Quality Status

In general, all groundwater bodies are considered to be a potential source of drinking water. The federal Safe Drinking Water Act standards, called Maximum Contaminant Levels, are applied when evaluating potential impacts of different pollutant sources and setting remediation or clean-up levels (Nevada Division of Environmental Protection, 1998b).

Though substantial groundwater quality monitoring is conducted by various agencies, these data are not managed in a statewide database. The U.S. Geological Survey National Water-Quality Assessment Program (NAWQA) recently published a comprehensive groundwater quality assessment report. The NAWQA study area in Nevada includes the Las Vegas Valley area, the Carson River Basin, and the Truckee River Basin. These basins were selected for an intensive sampling and assessment project because they contain more than 90 percent of Nevada's population; rapid population growth has increased competition for limited water supplies; and, natural and human-caused water-quality problems are evident (U.S. Geological Survey, 1998).

A number of important groundwater quality findings were reported in the study. Many of the shallow monitoring wells and deeper water supply wells sampled in urban areas contained low levels of pesticides and volatile organic compounds. However, pesticide occurrences in shallow wells located in agricultural areas were lower than in the urban areas. Similarly, sampling of shallow wells in agricultural and urban areas showed that the latter contained higher levels of nitrates. Some urban shallow wells contained nitrate levels exceeding the safe drinking water standard. Deeper supply wells tested contained elevated nitrate concentrations, but all were below the standard of 10 milligrams per liter. The significance of these findings is that shallow water-table aquifers can be linked to deeper drinking water aquifers.

The incidence of elevated nitrate levels in aquifers underlying suburban and rural subdivisions has increased. New homes and businesses built outside urban areas often use individual septic systems, which at the time of construction appear to be a cost effective alternative to community wastewater treatment systems. In some valleys, septic systems have become concentrated, especially where piecemeal (parcel map) subdivision development is allowed. Of special concern are subdivisions on septic systems that use local groundwater sources for domestic or community drinking water supply. A study of groundwater beneath un-sewered subdivisions in valleys north of Reno found that contaminant plumes expand rapidly when the combined domestic well pumpage exceeds annual groundwater recharge. The study suggested that septic system seepage was a major source of recharge and was contributing to elevated nitrates. In the studied valleys, 20 percent of the 250 sampled domestic wells contained water near or above the nitrate drinking water standard (Washoe County Department of Public Works and Desert Research Institute, circa 1995).

Elevated nitrate levels have been found in shallow groundwater bodies underlying twenty-three residential subdivisions (Nevada Division of Environmental Protection, 2001b). Currently only six communities are known to have public supply wells with elevated nitrates, and only two of these have had to take actions that reduce nitrate levels because the drinking water supply standards were exceeded (Nevada Division of Environmental Protection, 2001b). Domestic well quality data is not compiled by state agencies, but homeowners are advised to have domestic well water analyzed periodically at a certified lab. Alternative solutions to the problem of high nitrate levels in groundwater include closure of individual septic systems with connection to community wastewater treatment systems; switching from a domestic well supply source to a public water supply system; or, pumping groundwater for irrigation uses to contain the zone of high nitrates. Cooperation between state, local, and property owners is necessary to improve impaired groundwater supplies in suburban and rural communities.

Well Head Protection

As more homes and businesses rely on groundwater, pollution prevention has become increasingly important. In 1994, the Division of Environmental Protection set up the Wellhead Protection Program (WHPP) that gives local communities technical guidance for long-term drinking water source protection. Though not required, many communities already have prepared local WHPP's. The wellhead protection framework involves identifying the land surface area that should be managed to protect the groundwater being pumped; inventorying and mapping existing and potential contaminant sources located within that area; and, selecting appropriate management strategies.

Common potential contaminant sources include underground storage tanks, improperly abandoned wells, improperly applied fertilizers and pesticides, and high concentrations of septic systems. Management options might include regulations such as zoning ordinances, or non-regulatory options such as public education. A WHPP also can include plans for dealing with emergencies or accidental contaminant releases. Because pollutants come from many smaller sources (e.g., residential lawns, commercial parking lots, and individual septic systems) that are difficult to oversee, public education and participation is a critical element of WHPP.

Since 1994, 27 water systems or communities have prepared wellhead protection plans. This number is projected to increase to 32 during 2001 (Bureau of Water Quality Planning, 2001). The program is voluntary, so data is not available on the number of communities that have progressed with plan implementation. Implementation challenges include limited local government funds, additional public and private costs, and concern that limitation might be placed on land uses within a wellhead protection zone.

Underground Injection Control

The Underground Injection Control (UIC) Program is another federal program for which the State of Nevada has accepted responsibility. The goal of the program is to protect Nevada's groundwater resource from potential degradation by the injection of fluids into a well. Injection of fluids is allowed for various purposes. One is injecting water to boost groundwater supplies, known as Aquifer Storage and Recharge (ASR). Nevada's UIC program regulates the injection of fresh, potable water into drinking water aquifers where it is stored for use at a later date.

Fluids also are injected for groundwater remediation. Contaminated water can be pumped, treated, and then returned to the aquifer. Another type of injection activity introduces nutrient enriched fluid into a polluted aquifer to stimulate bacterial decomposition of the contaminants. Biodegradation is a prominent means of re-establishing the beneficial use of groundwater where oil, gas and petroleum byproducts have leaked or spilled.

Geothermal energy is used at Empire Farms to process garlic and onions, in addition to generating electricity. The photo shows the pond and drying facility in the background. Photo courtesy of Larry Garside, Empire Farms. 2001

Nevada's geothermal resources, used for electricity generation, space heating, and industrial processes, are regulated under the UIC program. After use, the spent geothermal fluid is re-injected into the aquifer of origin, where feasible. Care must be taken to avoid both contamination of adjoining aquifers with higher quality water and accelerated cooling of the natural reservoir of hot or warm water. Open pit mines that dewater and then return groundwater to the aquifer are also covered under the UIC Program.

Leaking Underground Storage Tanks, Spills, and Brownfields

Contaminated properties most often involve industrial or commercial activities that have released chemicals. Nevada law requires owners to report contamination events to the state Division of Environmental Protection (NDEP) and to take necessary remedial action at the site. The most serious long-term clean up projects occur where contamination moves through the soil and contaminates groundwater. Leaking underground petroleum storage tanks are responsible for most of the cleanup sites in Nevada. To comply with state administered regulations established under the federal Resource Conservation and Recovery Act, older tanks were to have been removed or upgraded by December 1998. Each year, fewer contaminated sites are being found, and more sites are being cleaned up. Consequently, the number of open sites with ongoing corrective action is declining.

The Petroleum Fund and the Underground Storage Tank/Leaking Underground Storage Tank (UST) Programs provide incentives and regulatory oversight for cleanup activities. The programs are implemented by the Bureau of Corrective Actions, which operates under regulations requiring cost benefit evaluations prior to clean up actions. In fiscal year 1999, the Bureau opened 88 new Petroleum fund cases, closed 191 cases, and disbursed approximately $ 4.98 million in Petroleum fund monies. In fiscal year 2000, 60 new cases were opened, 3 were closed, and $ 6.04 million dollars were disbursed (Nevada Division of Environmental Protection, 2000).

Since the 1992 inception of a formalized remedial action program, approximately 1,097 non-UST sites have been investigated and cleaned up to State requirements. These cases involved petroleum products, heavy metals, organic compounds, pesticides and PCB's. Approximately 125 cases are open and active at any given time. Remediation efforts continue in Washoe County to investigate the extent of ground water contamination by cleaning solvents in Downtown Reno. Monitoring activities indicate the need for additional remediation efforts, which are underway. Sampling was conducted near the Yerington Anaconda mine project to determine if the mine has impacted any down gradient municipal or private wells. Sampling results indicated that there were no impacts on these wells. Cleanup activities at the Rio Tinto mine in northern Elko County are continuing. Major cleanup efforts at the BMI industrial complex in Henderson have begun to remediate contamination and turn the site into a master planned community.

About 500 spills are reported annually. More than half occur in the heavily populated southern and western part of the state. Prompt cleanup of hazardous substance spills reduces danger to public safety and prevents spill sites from becoming contaminated properties. Most spills are small. While quantity can be important, the properties of the substance spilled and the location of the spill are generally more critical factors. The most common substances spilled are petroleum products. Nearly 75 percent of all spills impact the soil. Excavating the contaminated soil and refilling with clean soil usually cleans up these spills. When a spill impacts surface water or groundwater, it presents a greater risk and requires a more intensive response.

State and federal environmental protection agencies are teaming up to accelerate the clean up of contaminated lands. The Brownfields Program applies to contaminated property that has been abandoned or under-used. Putting these brownfield properties back into productive use returns them to the tax base, brings jobs to populated areas, and helps conserve other land for farming, recreational areas, and green space. The NDEP-operated program advises property buyers and sellers, local governments, lenders, and developers about legal and technical options that will get the cleanup done and help ensure that land development does not hopscotch around the brownfield sites. Advanced monitoring and contaminant transport modeling technologies will be used by NDEP that raise the certainty that remediation of a contaminated site has been successful. The Nevada State Legislature in 1999 passed the Program for Voluntary Cleanup of Hazardous Substances and Relief From Liability. The purpose is to encourage voluntary cleanup of contaminant releases and remove the stigma of potential liability for future landowners and lenders. The Voluntary Cleanup Program will result in clearing the pathway for returning these properties to beneficial use in a timely and efficient manner.

Drinking Water Supply

Chances are great that the tap water you use for drinking and domestic purposes comes from a public water system. In 1999, 97 percent of Nevada's citizens were served by one of 670 public water systems. Public water systems can be small, with as few as 15 connections or 25 people, or large, serving hundreds of thousands of people. Cities, towns, casinos, campgrounds, restaurants, schools, mines, and factories are served by public water systems. Ensuring that water delivered by public systems meets drinking water standards is vital to the public health, welfare, and economy. Reducing outbreaks of waterborne disease and chemical poisoning, and increasing the proportion of people who receive a supply of drinking water that meet Safe Drinking Water Act standards established by the U.S. Environmental Protection Agency (EPA), are two of the Department of Health and Human Services' objectives.

EPA has set drinking water maximum contaminant levels (MCL) for 90 substances, establishing safe limits for public water supplies. However, many contaminants in drinking water have no MCL's. Furthermore, combinations of chemicals in drinking water can have health impacts that are not well understood yet. As a result, preventing contamination of sources of drinking water supply is a critical concern. Public water system operators must monitor drinking water for microbiological and chemical contaminants regulated under the Safe Drinking Water Act (SDWA) to ensure drinking water standards are not exceeded. Monitored chemicals include nitrogen compounds, metals, pesticides, solvents, petroleum byproducts, and radon. As a precautionary measure, drinking water in Nevada is monitored for about 50 additional organic chemicals for which standards have not been set.

When a public water system violates a drinking water standard, it must notify the public, identify the source of the problem, take necessary corrective action and resample. Public water systems in Nevada have done well in providing clean water. In 1999, seven public water systems generated seven chemical violations (arsenic, antimony and nitrate) and 71 systems generated 89 microbial violations, only three of which were acute. Of the 670 public water systems in the state, 89 percent reported no contaminant levels that exceeded the standards (Nevada Health Division, 1999).

Wastewater Treatment and Reuse

The ground water and surface water discharge program administered by the NDEP plays a leading role in protecting the quality of Nevada's natural water supplies. The Bureau of Water Pollution Control issues permits for the discharge of treated wastewater (sewage) under the state groundwater protection program and National Pollution Discharge Elimination System (NPDES) program. The U.S. Environmental Protection Agency (EPA) delegated responsibility for the NPDES program to Nevada. The discharge of treated wastewater to surface waters is regulated through pollutant limits in discharged water, best available treatment technology guidance, monitoring, and reporting.

Similar to the NPDES program, the state groundwater protection program protects the quality of underground aquifers through a permitting and inspection system for treated wastewater discharged into rapid infiltration basins and evaporation ponds. The reuse of highly treated wastewater (reclaimed water) for irrigation is another type of discharge to groundwater that has become more common. Properly treated and applied, reclaimed water is a safe and economical irrigation alternative to using limited groundwater and surface water supplies. An environmental benefit of using reclaimed water for irrigation is the reduction in pollutant discharges into Nevada's rivers and lakes. The number of permits in effect for reclaimed water uses reached sixty-five in 2000. An applicant proposing to use reclaimed water must submit an effluent management plan (EMP) which details how the reclaimed water will be applied to the site. The EMP lists health safeguards for irrigation and application rates. Health safeguards include aerosol drift controls, public notification, and protection of water supplies.

Reclaimed water is applied throughout the state for irrigation of parks, golf courses, and agricultural lands. Other uses of reclaimed water include dust control on unpaved roads and construction sites, soil compaction, and power plants. In Carson Valley, treated wastewater piped from communities in the Lake Tahoe Basin supplies water for wetlands and agricultural uses. In some circumstances, a new use of reclaimed water for irrigation results in less water returned to a surface water body. Any beneficial use of reclaimed water requires two permits from the State Engineer: a primary permit on the source (i.e., waste water treatment facility) and a secondary permit for the beneficial use.

Wastes and Environmental Contaminants

Solid and Hazardous Waste

During the past decade, Nevada has implemented federal laws that regulate municipal landfills. The Bureau of Waste Management (BWM) in the NDEP administers the federal regulations. More than 60 open dumps have been closed, replaced with a network of transfer stations and 22 regional landfills. The transfer stations and regional landfills are designed and operated to safely contain waste and prevent contaminants from reaching groundwater.

The amount of municipal solid waste (MSW) disposed of in landfills continues to grow each year, roughly proportional to the growth in population. However, generation of MSW per capita in Nevada at nine pounds per person per day is twice the national average of 4.5. The amount of solid waste delivered to solid waste disposal sites increased almost five percent annually from 1998 to 2000 (Table 2-6). Not included in the total is MSW imported from California. Of the 4.8 million tons of the MSW disposed of in 2000, about 11 percent originated in another state. Almost all imported waste was accepted at the privately owned Lockwood Regional landfill, near Sparks. A small amount is accepted at landfills by Mesquite and West Wendover (Bureau of Waste Management, 2001a).

Table 2-6. Tons of Solid Waste Delivered to Solid Waste Disposal Sites, 1998 – 2000

Category of Waste	1998	1999	2000*
	Tons per year		
Municipal Solid Waste from In-State Sources	3,003,261	3,152,658	3,308,512
Municipal Solid Waste from Out-of-State Sources	231,257	449,617	544,307
Industrial and Special Waste	941,749	1,013,946	914,572
State Total	4,176,267	4,616,221	4,767,391

Source: modified from Nevada Recycling Status and Market Development Report, Bureau of Waste Management, 2001.
Notes: *Year 2000 data is estimated, since five percent of the fourth quarter reports had not been received. The Industrial and Special Waste category includes several types that require special management at permitted landfills. Ninety percent of this waste type is construction and demolition debris.

The BWM calculates the recycling rate in Nevada each year. State laws require municipalities to operate recycling programs at varying levels, depending upon population. Recycling must be offered to residential premises and public buildings where solid waste collection is provided. However, participation in the programs is voluntary. The statutory goal for municipal recycling is 25 percent. Statewide, the MSW recycling rate has trended downward, falling from 14.5 to 11.3 percent between 1996 and 1999. The 50-state average is 28 percent.

Washoe and Carson City county recycling rates approximated 21 percent in 1999, but Clark County's rate was 8.3 percent. Nevada's tourist-based economy, coupled with low waste disposal costs at most landfills contributes to high waste generation and a low recovery rate for recyclables. Slumping prices for recyclable commodities is another reason for falling recycling rates. The NDEP participates with the Nevada Commission on Economic Development and its contractors to promote recycling market development. A number of significant obstacles have blocked progress in developing recycling markets, including few industries that might use recycled materials, a tourism economy, and large distance between urban centers (Bureau of Waste Management, 2001b).

Almost 80 facilities in Nevada generate enough hazardous waste per month (more than 1,000 kilograms) to be designated as a large quantity generator. Approximately 350 facilities are designated as small quantity generators of hazardous waste. Three commercial facilities are permitted to treat, store or dispose of hazardous waste, located at Beatty, Fernley, and North Las Vegas. Certain federal facilities, including the Nevada Test Site and Hawthorne Army Depot, have permits to manage hazardous waste on-site. The only land disposal site for hazardous waste is the state-owned Beatty facility operated under lease agreement by US Ecology, Inc. This 80-acre facility located south of Beatty, has received both low-level radioactive waste and chemical waste since the 1960's. The radioactive waste portion of the site closed in 1992. Currently, the facility receives limited types and quantities of hazardous waste. The remaining capacity is limited (Bureau of Waste Management, 2001a).

Legacy Wastes

Collectively, the federal facilities in Nevada have caused significant degradation to the environment. A large portion of the Nevada Test Site will remain restricted, requiring "in perpetuity" institutional control. The NTS was the site of 100 above ground "atmospheric" nuclear tests followed by 800 underground tests. Underground testing has contaminated groundwater over vast areas. Nearly 30 percent of the underground tests were conducted near or below the groundwater. State officials now estimate that an area more than 300 square miles is contaminated beneath the site. Surface soils at NTS are also contaminated with various radionuclides. At least 30,000 acres will remain permanently restricted for all uses at the site.

Contamination at the various military bases is generally limited to site-specific industrial contamination, such as solvents and aviation fuels in shallow aquifers. Included are Hawthorne Army Depot, Nellis Air Force Base, and Fallon Naval Air Station. Surface and sub-surface contamination at the various bombing and testing ranges is considered significant, including the Nellis Test and Training Range and the Fallon Range Training Complex. However, because of high costs or limited cleanup technologies, or both, many of the bombing ranges likely will never be remediated. Most of the range contamination is in the form of un-exploded ordnance and represents a significant safety hazard and potential long-term environmental risk.

Federal officials, with state government oversight, are expending considerable funds to characterize and remediate groundwater and surface soil contamination, where feasible at the respective federal facilities. At military bases, federal funds are allocated each year to address site-specific cleanup and closure activities (e.g., industrial site cleanups). About 160 contaminated sites on the military bases are under various degrees of investigation and remediation. Since most of the military bombing ranges in Nevada are active, remediation at air-to-ground bombing and testing ranges is limited to annual surface cleanup of un-exploded ordnance, scrap metals, and target debris.

The NDEP oversees site remediation activities at the national defense sites. In the early 1990's, NDEP established the Bureau of Federal Facilities to oversee remediation and focus clean-up activities at DOD and DOE facilities in Nevada. NDEP officials evaluate remediation plans, conduct site visits, and provide regulatory oversight. State concurrence is required to close sites where contamination is left in place. At the present time, the respective DOD entities are expending about $2 million annually on legacy waste site cleanup and remediation activities.

At the Nevada Test Site, federal and state officials are evaluating groundwater contamination caused by underground nuclear testing. Some of the contaminants are mobile in water, such as tritium. Because radionuclides have decay periods measured in thousands of years, monitoring groundwater flows beneath the site is of particular concern. The DOE is spending about $30 million annually to characterize, model, and define compliance boundaries of contaminated units beneath the site. The State, under a consent order administered by NDEP, provides regulatory oversight of the DOE groundwater and surface soil investigation programs. Site monitoring activities are anticipated to extend beyond 2030.

References

Bureau of Air Quality (NDEP). 2000. Bureau of Air Quality 1989 – 1999 Trend Report.

Bureau of Waste Management (NDEP). 2001. Nevada Recycling Status and Market Development Report.

California Department of Water Resources (a). 1991. Carson River Atlas.

California Department of Water Resources (b). 1991. Truckee River Atlas.

California Department of Water Resources (c). 1992. Walker River Atlas.

Frederick, Kenneth D. and Peter H. Gleick. 1999. *Water and Global Climate Change, Potential Impacts on U.S. Water Resources*. Prepared for the Pew Center on Global Climate Change.

Interagency Abandoned Mine Land Environmental Task Force, 1999. *Nevada Abandoned Mine Lands Report*. Prepared by the U.S. Bureau of Land Management and Nevada Division of Minerals.

Nevada Department of Transportation. 2001. Personal communication. Estimated Annual Vehicle Miles Traveled Data Tables.

Nevada Division of Environmental Protection, 1998a. *Nevada Water Quality Assessment 305(b) Report*.

Nevada Division of Environmental Protection. 1998b. Comprehensive State Groundwater Protection Program, Profile, Updated March 1998.

Nevada Division of Environmental Protection. 2000. *Nevada Division Environmental Protection 2000 Biennial Report*. Internet address: http://ndep.state.nv.us/admin/report98.htm

Nevada Division of Environmental Protection. 2001a. Personal communication with Bureau of Water Quality Planning. Tabulated Summary of Impaired River Miles – 1998 303(d) List.

Nevada Division of Environmental Protection. 2001b. Personal communication with the Bureau of Water Quality Planning. Survey of groundwater quality data on elevated nitrate levels.

Nevada Division of Water Planning. 1999a. Nevada State Water Plan, Summary.

Nevada Division of Water Planning, 1999b. Nevada State Water Plan, Part 3 – Water Planning and Management Issues.

Nevada Energy Office and Desert Research Institute (DRI). 1998. Greenhouse Gas Emissions Inventory for Nevada, Phase I Report Estimates for 1990 and 1995. DRI Document No. 98-8380.DF.2.

Nevada Health Division. 2001. Personal communication with the Bureau of Health Protection Services.

Nevada Health Division. 1999. Annual Compliance Report for the State of Nevada Public Water Systems.

U.S. Bureau of Reclamation. 1998. Working Draft of the Truckee River Operating Agreement EIS/EIR.

U.S. Environmental Protection Agency. 2002. Global Warming Website. Internet address http://www.epa.gov/globalwarming/index.html

U.S. Geological Survey. 1998. Water Quality in the Las Vegas Valley Area and the Carson and Truckee River Basins, Nevada and California, 1992 – 1996. Circular 1170.

Washoe County Department of Public Works, Utility Division, and Desert Research Institute, Water Resource Center. Circa 1995. Groundwater Contamination from Septic Tank Effluent in a Closed Basin, Washoe County, Nevada.